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'HISTORICAL ELOGE OF JAMES WATT'
Publ. 1839

(B: 1736, D: 1819
- CELEBRATED SCOTCH ENGINEER & INVENTOR OF THE CONDENSING STEAM ENGINE)

$35.00

HISTORICAL ELOGE

OF

JAMES WATT.

EDINBURGH : PRINTED BY T. CONSTABLE,

PRINTER TO HER MAJESTY.

HISTORICAL ELOGE

OF

JAMES WATT

BY

M. ARAGO

PERPETUAL SECRETARY TO THE ACADEMY OF SCIENCES.

TRANSLATED FROM THE FRENCH

WITH ADDITIONAL NOTES AND AN APPENDIX

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ADVOCATE.

LONDON: JOHN MURRAY.

EDINBURGH: WILLIAM BLACKWOOD AND SONS.

M.DCCC.XXXIX.

PREFACE.

In 1699, Louis XIV. gave to the Academy of Sciences a new code of laws, by which several important changes were introduced into the constitution of that Society.

Of these, one of the most novel, was the admission of *Foreign Associates*. These were never to exceed eight in number, and were to be chosen without regard to any other considerations than their scientific fame, and the integrity of their lives. Hence, the honour of being admitted into that very distinguished class, has always been esteemed a reward of the most eminent philosophical attainments; and "the list of Foreign Associates," says Cuvier, "commencing with the names of Newton, Leibnitz, and Peter the Great, has never degenerated from its original splendour."*

In 1814, the name of James Watt was added to this illustrious catalogue; and, some years after

* Eloge of Priestley.

his death, the duty of preparing an Historical Eloge, or biographical memoir, in which his scientific career, and the sense which his fellow-members entertained of his loss, should be recorded, devolved upon the Perpetual Secretary, M. Arago. That Eloge was read at the public meeting of the Academy of Sciences, on the 8th of December, 1834.

If the title of this work requires any further explanation, it may be given in the words of Fontenelle, who, more than a century ago, filled the same office which M. Arago now holds, and published the Eloges of many Academicians. "The title of Eloges," says he, "is not quite so correct as that of *Lives* would be; for they are, strictly speaking, merely Lives, such as would be written by an author who only did justice to their subjects."

The well-known abilities of M. Arago, himself a distinguished cultivator of the same sciences as the great philosopher whom he here commemorates, have been exercised with even more than their usual success, on the congenial topic thus presented to him. He has explained many most important inventions, involving numerous and minute scientific details, with so much simplicity and precision, as to render them intelligible, and therefore interesting, to every reader; while his peculiar felicity of illustration and powers of

diction, lend additional attractions to the knowledge so conveyed. To the latter characteristics of his style, no translation can do justice; and the difficulty or impossibility of transferring from the French to the English language those graces of idiom and expression, in which the former so much abounds, must serve as the excuse for imperfections, which in the following pages will doubtless be observed.

To some, it may appear, that M. Arago, in his history of the early improvers of the Steam Engine, has dwelt too much on the names of De Caus and Papin. Perhaps he may in return consider, that our notes on those who have in this country always been looked upon as the real originators of *the great machine*, have entered into further details than were required to establish their claims and set forth their merits. But as, on the one hand, the patriotic ardour for which M. Arago is celebrated, has been well employed in asserting the reputation which his country may deserve; so, on the other, we feel quite assured, that his liberality of sentiment, and desire of rendering impartial justice to all, will easily reconcile him to the nationality which he may possibly think he discerns on our part.

In the Appendix to this translation, the Historical Note by Lord Brougham on the discovery of

the composition of water, is followed by the eloquent delineation of the Character of Mr. Watt by Lord Jeffrey ; to which those who had known Mr. Watt longest and best, have concurred in ascribing the merit of an unrivalled fidelity.

Of the speeches delivered at the meeting at which the statue in Westminster Abbey was voted, it was at first proposed only to have given some extracts. But it was found that the effect of those speeches must have been infinitely injured, by their being at all curtailed ; and as they do the highest honour not only to the memory of Mr. Watt, and the talents and feelings of the distinguished speakers, but also to the Nation whose gratitude they were intended to express, the Report of the Committee has been reprinted without abridgement or alteration.

The able Dissertation on Machinery considered in relation to the welfare of the working-classes, formed originally a part of the body of the Eloge ; and was inserted immediately after that chapter which treats of the History of the Steam-Engine. But, as its introduction there seemed somewhat to interfere with the continuity of the history of Mr. Watt's life and inventions, it has now been, perhaps more appropriately, placed after the other parts of this volume in which those are more immediately noticed.

For much of the information contained in the Additional Notes, the Translator has to thank the goodness, (which M. Arago might well call unwearied), of his friend the present Mr. James Watt; who has always viewed as a sacred trust the guardianship of that name which he inherits, and which is now perpetuated, in every quarter of the world, by benefits conferred on mankind, such as lead to the greatest and most imperishable renown.

Edinburgh,
12*th November* 1839.

HISTORICAL ELOGE, &c.

After perusing the long catalogue of battles, of murders, of pestilences, of famines, of catastrophes of every kind, which the annals of I know not what country presented, a philosopher exclaimed, "Happy is the nation whose history is tiresome!" Why must we add, at least in a literary point of view, "Unfortunate is the man on whom devolves the duty of narrating the history of a happy people!"

If the philosopher's exclamation loses nothing of its force when applied to simple individuals, its counterpart expresses, with equal truth, the situation of some biographers.

Such were the thoughts which occurred to me, while I was studying the life of James Watt, and collecting the kind communications of the relations, friends, and associates, of that illustrious mechanician. That life, quite patriarchal, devoted to labour, to study, to meditation, will present us with none of those exciting events, of which

the narration, interspersed with a little skill among the details of science, relieves their gravity. Yet I will relate it, were it only to show in what a humble condition projects were elaborated, which were destined to raise the British nation to an unheard-of height of power. I shall endeavour, above all, to describe with minute accuracy the fertile inventions which for ever connect the name of Watt with that of the steam-engine.

I am perfectly aware of the dangers of this course. I foresee that it may be said, on leaving this place, "We expected an historical eloge, and we have been present at a dry and tedious lesson." But if the lesson were comprehended, I should stand in but little dread of the reproach. I shall, therefore, use every endeavour not to weary your attention. I shall bear in mind that the good breeding of those who address the public consists in perspicuity.

THE CHILDHOOD AND YOUTH OF JAMES WATT; HIS PROMOTION TO THE OFFICE OF MATHEMATICAL INSTRUMENT MAKER TO THE UNIVERSITY OF GLASGOW.

James Watt, one of the eight Foreign Associates of the Academy of Sciences, was born at Greenock, in Scotland, on the 19th of January 1736. Our neighbours on the other side of the channel have the good sense to be of opinion, that the genealogy of a respectable and industrious family

is quite as deserving of preservation as the parchments of certain titled houses, which have attained celebrity only by the enormity of their crimes or their vices. Hence I am enabled to state with certainty, that the great-grandfather of James Watt was a farmer, living in the county of Aberdeen ;—that he perished in one of the battles of Montrose ;—that the victorious party, as was then, —I had almost said as is still,—the practice in civil contentions, held death to be no sufficient atonement for the opinions for which the unfortunate farmer had fought ; that they punished him in the person of his son, by confiscating his little property ; that this poor orphan, Thomas Watt, was taken under the care of distant relations ; that in the complete seclusion into which he was driven by the difficulties of his situation, he devoted himself assiduously to study ; that in more tranquil times he established himself at Greenock, where he taught mathematics and the elements of navigation ; that he lived in the adjoining burgh of Crawford's Dyke, of which he was for several years the chief magistrate or baron-baillie ; and finally, that he died in 1734, at the age of ninety-two.*

Thomas Watt had two sons. The elder, John, followed, at Glasgow, the profession of his father. He died, aged fifty, in 1737, leaving a survey of the course of the Clyde, which was published by his brother James. This latter, the father of the

* In the inscription upon his tomb, in the West Churchyard at Greenock, he is styled "Professor of the Mathematicks."—TRANSLATOR.

great engineer, was for upwards of twenty years a member of, and during great part of the time treasurer to the Town-Council of Greenock, a magistrate, and distinguished by an ardent zeal and enlightened spirit in promoting the improvements of the town.*

He united,—(*il cumulait*,† be not alarmed; this expression, which has become in France, at the present day, a universal cause of anathema, will do no injury to the memory of James Watt)—he united three kinds of occupations; he was at once a ship-chandler, supplying vessels with nautical apparatus, stores and instruments, a builder, and a merchant. This, unfortunately, did not prevent him, in consequence of certain commercial enterprises, undertaken towards the close of his life, suffering the loss of a portion of the honourable fortune which he had previously acquired. He died, at the age of eighty-four, in 1782.

James Watt, the subject of this eloge, was born with an extremely delicate constitution. His mother, whose family name was Muirheid, gave him

* We find in the minutes of the Town Council of Greenock, under date of 3d June 1774, that Mr. Watt then gave in his resignation of the office of a manager and councillor; upon which the meeting of the Magistrates and Council returned him thanks for the many good services he had done to the community. He was also agent to the late Lord Cathcart in the management of his property at Greenock, who, upon Mr. Watt's death, bore honourable testimony to his memory, in a letter to his son.—Tr.

† *Il cumulait.* This refers to a current joke and bye-word among the members of the Academy, relative to a greed of places; from which it would appear that even philosophers are not exempt!—Tr.

his first lessons in reading. Writing and arithmetic he learned from his father. He also attended the public elementary school at Greenock. The humble grammar-schools of Scotland will thus have a right to inscribe, with just pride, the name of the celebrated engineer among those of the pupils whom they have trained; as the college of La Flèche could heretofore boast of Descartes, as the University of Cambridge still boasts of Newton.

To be exact, I ought to say, that continual ailments prevented young Watt from regularly attending the public school of Greenock; that for a great part of the year he was confined to his room, and there devoted himself to study without any assistance from others. As usually happens, the high intellectual faculties destined to bear such happy fruits, began to develope themselves in retirement and reflection.

Watt was of too sickly a habit for his parents to think of imposing any constant occupation upon him; they even left to him the free choice of his amusements. You will see presently whether he abused this licence.

A friend of Mr. Watt one day found the little James stretched on the floor and drawing, with a piece of chalk, all sorts of intersecting lines. "Why," he said, "do you allow this child to idle away his time in this manner? Send him away to the public school." Mr. Watt replied, "you may find, Sir, that you are mistaken;—before you blame me, examine attentively what my son is about."

Amends was speedily made;—the boy of six years old was trying to solve a problem of geometry.*

Guided by his enlightened affection, the father had early placed a certain number of tools at the young scholar's disposal, who made use of them with the greatest address, taking to pieces and putting together again the children's toys which fell into his hands, and continually making new ones. Afterwards, with these he constructed a small electrical machine, the brilliant sparks from which became a subject of much amusement and surprise to all the companions of the poor invalid.†

Watt, though possessed of an excellent memory, might, perhaps, have made no distinguished figure among the little prodigies of ordinary schools. He would have refused to learn lessons like a parrot, because he felt the necessity of sedulously working out the intellectual elements which were set before his mind; because he was specially formed by nature for meditation. James Watt, however, augured very favourably of the nascent faculties of his son; more distant and less quick-sighted relations did not share in the same hopes. Sitting one evening with his aunt, Mrs. Muirheid, at the tea table, she said, "James Watt, I never

* Upon this occasion Mr. Watt's friend put various questions to the boy, was astonished and gratified with the mixture of intelligence, quickness, and simplicity displayed in his answers, and used the remarkable expression, "*This is no common child.*"—Tr.

† This must have been about the years 1750–53. It will be recollected that the Leyden Phial was invented in the years 1745–46. See Priestley's History of Electricity, p. 80, edit. 1769.—Tr.

saw such an idle boy; take a book or employ yourself usefully; for the last hour you have not spoken one word, but taken off the lid of that kettle and put it on again, holding now a cup and now a silver spoon over the steam, watching how it rises from the spout, and catching and connecting the drops it falls into; are you not ashamed of spending your time in this way?"

In the year 1750, each one of us, in the same situation as Mrs. Muirheid, would, perhaps, have used the same language. But the world has made a stride, and our knowledge has grown greater; and so, when I shall immediately explain to you that the principal discovery of our fellow-member was a particular mode of converting steam into water,* Mrs. Muirheid's reproof will present itself to our minds under a totally different aspect; the little James before the tea-kettle, becomes the mighty engineer preluding to the discoveries which were to immortalise him; and it will, by every one, undoubtedly be deemed worthy of remark, that the words CONDENSATION OF STEAM should naturally have come to find a place in the history of Watt's early childhood. But, if I am led astray by the singularity of the anecdote, it is not the less worthy of being preserved. When opportunity offers, let us prove to youth that Newton was more than merely modest, when, to satisfy the curiosity of an illustrious personage who desired to know how attraction had been discovered, he answered, "by always thinking about it." In those simple

* The condensation of steam in a separate vessel.—TR.

words of the immortal author of the Principia, we may lay open to the eyes of all the true secret of men of genius.

The spirit of anecdote, which, for more than half a century, our fellow-member so gracefully displayed among all by whom he was surrounded, manifested itself very early. You will find a proof of this in these few lines, which I have extracted from an unpublished memorandum committed to writing, in 1798, by Mrs. Marion Campbell, the cousin and early companion of the celebrated engineer.*

"His mother brought him to Glasgow to visit a friend, under whose care he was left. On Mrs. Watt's return to Glasgow, some weeks after, without any idea of the reception which awaited her, her friend said, 'you must take your son James home, I can no longer bear the state of excitement in which he keeps me; I am worn out with want of sleep. Every evening, before our usual hour of retiring to rest, he adroitly contrives to engage me in conversation, then begins some striking tale, and, whether it be humorous or pathetic, the interest is so overpowering, that all the family listen to him with breathless attention; hour after hour strikes unheeded, but the next

* For this curious document I am indebted to my friend Mr. James Watt of Soho. Thanks to the profound veneration he has always entertained for the memory of his illustrious father; thanks to the unwearied goodness with which he has answered all my demands, I have been enabled to correct a variety of inaccuracies such as have found their way into the most esteemed biographies, and which I myself, misled by oral communications, received with too little caution, was at first unable to avoid.—M. Arago.

morning I feel quite exhausted. You must, really, take home your son.' "

James Watt had a younger brother, John, who, in resolving to pursue his father's business, left to his elder brother, as is usual in Scotland, liberty to follow his call. But that call it was difficult to discover, for the young student occupied himself with every thing, with equal success.*

The banks of Loch Lomond, already rendered so famous by the recollections of Buchanan the historian, and of the illustrious inventor of logarithms, developed his taste for the beauties of scenery and for botany. His rambles over various mountains of Scotland, taught him to perceive that the inert crust of the earth no less deserves our attention, and he became a mineralogist. He entered the cottages of the poor to study their characters, and listen for hours to their local traditions, popular ballads, and wild superstitions. When bad health confined him under the paternal roof, chemistry was the principal subject of his experiments. 'S Gravesande's "Elements of Natural Philosophy"† also initiated him into the infinite marvels of general physics; and to conclude, like all invalids, he greedily perused all books on

* John perished, in 1762, in one of his father's ships, on the passage from Greenock to America, at the age of twenty-three.—M. Arago.

† "Physices Elementa Mathematica experimentis confirmata, sive Introductio ad Philosophiam Newtonianam. Auctore Gulielmo Jacobo 's Gravesande, A.L.M. Jur. Utr. et Phil. Doctore, Regiae Societ. Lond. Socio; Astron. et Math. in Acad. Lugd. Bat. Professore ordinario. Lugduni Batavorum, M.DCC.XX. 2 vols. 4to." This work was translated into English in the same year, and afterwards went through many editions in that language.—Tr.

medicine and surgery which he could procure. These latter sciences had excited such a passion in the mind of the student, that he was one day caught in the act of carrying into his room, for dissection, the head of a child who had died of an unknown disease.

Yet Watt did not destine himself either to botany, or to mineralogy, or to literature, or to poetry, or to chemistry, or to natural philosophy, or to medicine, or to surgery, though he was so well prepared for each of those kinds of study. In 1755, he went to London to place himself with Mr. John Morgan, mathematical and nautical instrument maker, in Finch Lane, Cornhill. The man who was to cover England with moving powers, beside which, at least as far as their effects are concerned, the ancient and colossal machine of Marly* would be but a pigmy, entered upon

* The Machine of Marly was erected at the village of that name upon the Seine, by Rennequin of Liege, for Louis XIV. in 1682, to raise water for the town and water-works of Versailles. This was effected by means of fourteen large water-wheels, and a series of pumps, pipes, cranks, and rods, remarkable for their complexity and the noise they made in working. In 1786-87, Mr. Watt and Mr. Boulton proceeded to Paris at the instance of the French Government, to suggest improvements on this machine, which were not carried into effect in consequence of financial difficulties, and the dismissal of the ministry. Since then, a steam-engine has been erected by the French to do part of the work; and two of the wheels, with improved apparatus, are all that remain of this cumbersome machinery. It is amusing, in the present state of hydraulic science, to read an account of the Machine of Marly, such as is given in Desaguliers:—"*When he*," says that writer, "*that comes to take a view of the engine at Marly, sees it cover a mile of ground in length, and the breadth greater than that of the whole river Seine—he cannot but look upon it as a stupendous machine.* * * * * *It is said that the Machine at Marly cost above*

his career of industry by constructing, with his own hands, fine, delicate, fragile instruments, those small but beautiful reflecting sextants to which the art of navigation owes its advancement.

Watt remained not quite a year with Mr. Morgan, and returned to Glasgow, where considerable difficulties awaited him. Taking their stand on their ancient privileges, the corporations of arts and trades looked upon the young artist from London as an intruder, and obstinately refused to allow him to set up even the humblest workshop. All conciliatory measures having failed, the University of Glasgow interfered, made a grant, in favour of young Watt, of a small room in their own buildings, permitted him to establish a shop, and honoured him with the title of their mathematical instrument maker. There still exist some small instruments of that date, of exquisite workmanship, executed entirely by the hand of Watt. I may add that his son has lately submitted to my inspection the first drawings of the steam-engine, and that they are truly remarkable for the neatness, the strength and the accuracy of their outline. It was, then, not without good cause that Watt piqued himself on his manual skill.

Perhaps you may think, and not altogether without reason, that I carry my particularity very far

eighty millions of French livres, which is above four millions of pounds sterling. Some of the largest of our fire-engines, at present [1744] *in use in England, will raise as much water to the same height, and not cost above ten thousand pounds.*" Desaguliers, Annot. upon Lecture XII. of his course of Experimental Philosophy.—TR.

in claiming for our fellow-member a merit which can hardly add to his glory. But I am not ashamed to confess that I never listen to the pedantic enumeration of the qualifications which eminent men have not possessed, without recollecting that bad General of the time of Louis XIV., who always kept his right shoulder very high, because Prince Eugène of Savoy was a little hump-backed, and thought that he thereby was exempted from trying to carry the resemblance further.

Watt had scarcely reached his twenty-first year when the University of Glasgow attached him to itself. His patrons were Adam Smith, the author of the famous work on the Wealth of Nations; Black, whom his discoveries with regard to latent heat and the carbonate of lime, raised to a distinguished place among the first chemists of the eighteenth century; Robert Simson, the celebrated restorer of the most important treatises of the ancient geometers.*

Those eminent persons at first thought, that they had rescued from the molestations of the corporate bodies only a skilful, zealous, and amiable artificer; but they were not long of recognising also the man of rare merit, and vowed to him the most ardent friendship. The students in the university shared also in the honour of being admitted

* Dr. Dick, the Professor of Natural Philosophy, might also with propriety have been included in this number. Mr. Watt and Dr. Robison were always accustomed to speak of him as a most able man. He was also Mr. Watt's strenuous friend, and it was through his recommendation that he went to Mr. Morgan.—Tr.

to the intimacy of Watt. In short, his shop—yes, *a shop!* became a sort of academy, whither all the learned of Glasgow resorted to discuss points of the greatest nicety in art, science, and literature. Indeed, I could not venture to tell you what a distinguished part was taken by the young artificer of twenty-one in those learned meetings, were it not that I am borne out by an unpublished notice of the most illustrious contributor to the Encyclopædia Britannica. "When I was as yet a young student," says Robison, "I had the vanity to think myself a pretty good proficient in my favourite studies of mathematical and mechanical philosophy, and, on being introduced to Watt, was rather mortified at finding him so much my superior. * * Whenever any puzzle came in the way of any of us, we went to Mr. Watt. He needed only to be prompted; every thing became to him the beginning of a new and serious study, and we knew that he would not quit it till he had either discovered its insignificancy, or had made something of it. * * * On one occasion, the solution of a problem seemed to require the perusal of Leupold's *Theatrum Machinarum;* and Watt forthwith learnt German. At another time, and for a similar reason, he made himself master of Italian. * * * When to the superiority of knowledge, which every man confessed, in his own line, is added the *naïve* simplicity and candour of Mr. Watt's character, it is no wonder that the attachment of his acquaintances was strong. I have seen something of the world, and am obliged to say, that

I never saw such another instance of general and cordial attachment to a person, whom all acknowledged to be their superior. But this superiority was concealed under the most amiable candour, and liberal allowance of merit to every man. Mr. Watt was the first to ascribe to the ingenuity of a friend things which were very often nothing but his own surmises followed out, and embodied by another. I am well entitled to say this, and have often experienced it in my own case."

It is for you to determine whether the honour of having uttered these last words is not as great as that of having inspired them.

The studies thus deep and various, into which the singular circumstances of his position incessantly threw the young Glasgow artist, never interfered with the labours of the work-shop. These he executed by day ; the night was devoted to theoretical researches. Trusting to the resources of his imagination, Watt seemed to find pleasure in the most difficult undertakings, and those for which he might have been deemed the least fitted. He was altogether insensible to the charm of music, and never learned to distinguish one note from another, —the *ut*, for instance, from the *fa*,—and will it be believed that he undertook to build an organ ? Yet the work was brought to a good end ; it is needless to say, that the new instrument displayed the most important improvements in its mechanical parts, in the stops, in the indicators and regulators of the strength of the blast ; but you will be astonished to learn, that its harmonic qualities were not

less remarkable, and delighted the best performers. Watt solved an important part of the problem; he found out the *temperament* assigned by a master of the art, by help of the phenomena of the beats of imperfect consonances, then very ill understood, and of which he could have gained no knowledge except from the profound, but very obscure work of Dr. Robert Smith of Cambridge.*

HISTORY OF THE STEAM-ENGINE.

I HAVE now come to the most brilliant period of Watt's life, and also, I am afraid, to the most difficult part of my undertaking. As to the immense importance of the inventions which are now to be the subject of my discourse, no doubt can possibly be entertained; but I fear that I cannot make them be appreciated as they deserve, without going into very minute numerical comparisons. In order that these comparisons, if indispensable, may be readily understood, I shall now lay before you, as briefly as possible, the nice doctrines of Natural Philosophy on which we shall have to rest them.

* See the article TEMPERAMENT in the Encyclopædia Britannica, which is given in Brewster's edition of Robison's Mechanical Philosophy, vol. iv. p. 412. The title of Dr. Smith's book is, "Harmonics, or the Philosophy of Musical Sounds, by Robert Smith, D.D., F.R.S., and Master of Trinity College, in the University of Cambridge." The first edition of this work was published at Cambridge in 1749; the second, much improved and augmented, at London in 1759.—TR.

By the effect of a mere change of temperature, water may exist in any one of three states, quite distinct from each other. These are the solid, the liquid, and the gaseous or vapour state. Below zero in the scale of the centigrade thermometer, [32° of Fahrenheit] water becomes ice; at 100°, [212° Fahrenheit] it turns rapidly into vapour; at all the intermediate degrees it is liquid.

A close observation of the points of transition from one of these states to another, leads to discoveries of the utmost importance, which form the key to the economical appreciation of steam-engines.

Water is not necessarily warmer than all kinds of ice; water may remain at a temperature of zero [centigr.] without freezing; ice may remain at zero without melting; but there is great difficulty in believing that this water and this ice, both at the same degree of temperature, both at zero, differ only in their physical qualities; or that no element, other than water, properly so called, distinguishes the solid from the liquid water. A very simple experiment will throw light on this mystery. Mix a kilogram* of water at zero, with a kilogram of water at 75°, centigrade. The two kilograms of mixture will have a temperature of $37\frac{1}{2}$ degrees; that is to say, the mean temperature of the two component liquids. The hot water is thus found to have retained $37\frac{1}{2}°$ of its former tem-

* A kilogram is 2·679514 lbs. troy, or 2·204857 lbs. avoirdupois.—Tr.

perature ;—it has communicated the other $37\frac{1}{2}^{\circ}$ to the cold water. All this is quite natural, and might have been anticipated.*

Let us, however, repeat the experiment with one single difference. In place of the kilogram of water at zero, let us take a kilogram of ice at the same temperature of zero. From the mixture of this kilogram of ice with the kilogram of water at 75°, will result two kilograms of liquid water, because the ice, steeped in hot water, will certainly be dissolved, and will continue of the same weight as before. But were you to attribute to the mixture, as in the former instance, a temperature of $37\frac{1}{2}^{\circ}$, you would be deceived ; the temperature here will only be zero,—there will remain no trace of the 75° of heat which the kilogram of water possessed ; these 75° will have separated the atoms of ice from each other, and will have blended with them, but without heating them in any way whatsoever.†

I have no hesitation in offering this experiment of Black as one of the most remarkable in modern

* " When hot and cold water are mixed together, the excess of heat contained in the hot water is equally distributed in an instant through the whole mixture, and raises the temperature of it according to the greatness of the excess of temperature, and the proportion which the hot water bore to the cold. If the quantities of hot and cold water are equal, the temperature is the middle degree between that of the hot and that of the cold." See Dr. Black's Lectures on Chemistry, vol. i. p. 122. Edit. 1803.—Tr.

† The fact is stated by Dr. Black in these words :—" I have, in the same manner, put a lump of ice into an equal quantity of water, heated to the temperature of 176°, and the result was that the fluid was no hotter than water just ready to freeze." Black, vol. i. p. 125.—Tr.

physics. The following are, in fact, its consequences :—

Water and ice, both at zero, [centigr.] differ intimately in their composition. The liquid contains more than the solid does, 75° of an imponderable body, which is called *heat*. These 75° are so well concealed in the watery mixture,—I had almost said in the watery alloy,—that the most delicate thermometer does not indicate their presence. Heat, not perceptible by our senses, not perceptible by the most sensitive instruments ; in a word, LATENT HEAT,—for this is the name it has received, —is, therefore, one of the constituent elements of bodies.

A comparison of boiling water, or water at 100° [centigr.] with the steam which issues from it, and the temperature of which is also 100°, leads, but on a far more extensive scale, to analogous results. At the instant of forming itself into the state of vapour at 100°, water, at the same temperature of 100°, is impregnated, under a latent form, under a form which is not perceptible by the thermometer, with an enormous quantity of heat. When the steam returns to a liquid state, this composition-heat is disengaged, and communicates itself to any thing in its way, which is capable of absorbing it. If, for instance, a single kilogram of steam, at 100°, be made to pass through 5·35 kilograms of water at zero, this steam becomes altogether liquid. The 6·35 kilograms, which are the result of the mixture, stand at 100° temperature. There enters, then, into the intimate composition of a kilogram

of steam, a quantity of latent heat capable of raising a kilogram of water (if prevented from evaporating), from 0 up to 535 centigrade degrees. This result will, no doubt, appear enormous, but it is certain; water, as steam, exists only in this condition; wherever a kilogram of water at zero is naturally or artificially converted into steam, it ought to gain, in order to its transformation, and in fact it does gain from surrounding bodies, 535° of heat. These degrees, as can never be too often repeated, are restored integrally by the steam to the surfaces of all sorts on which its ulterior liquefaction takes place. Here we have, as I may observe in passing, the whole secret of heating by steam. This ingenious process is very imperfectly understood, when it is imagined that the aqueous gas conveys to a distance, in the tubes through which it circulates, only sensible or thermometric heat; the chief effects produced are owing to the composition-heat, the concealed heat, the latent heat, which is disengaged at the instant that the contact of cold surfaces reconverts the steam from the gaseous to the liquid state.

We may now, then, rank heat among the constituent elements of steam. To obtain heat, we must burn some kind of fuel; steam has, then, a commercial value greater than that of the liquid, by the whole price of the combustible employed in the act of conversion into steam. If the difference between these two values is very great, it must be attributed principally to latent heat; ther-

mometric, sensible heat, enters into it only in a very small proportion.

I shall perhaps hereafter require to call to my support some other properties of steam. If I do not mention them at present, it is not because I attribute to this assembly the disposition of certain students, who said one day to their professor of geometry, "Why take the trouble of demonstrating these theorems? We have the most entire reliance upon you; give us your word of honour that they are true, and we shall be quite satisfied!" But I am anxious not to trespass on your patience; and I do not fail to remember, that by having recourse to particular treatises, you will easily more than supply the deficiencies which I must of necessity leave.

Let me in the meantime endeavour to advocate the cause of those nations and individuals who have a claim to be commemorated in the annals of the steam-engine. Let me trace the chronological series of improvements which this machine has received, from its first beginnings, now of great antiquity, down to the discoveries of Watt. I approach this subject with the firm resolution of being impartial,—with an ardent desire of rendering to each inventor that justice which is his due,—with an assured conviction that I shall remain unmoved by any feeling which could have its origin in national prejudices, disgraceful to the high office which you have assigned me, not less than to the majesty of science. While, on the other hand, I confess that I shall pay little heed to the many judgments al-

ready pronounced at the bidding of such prejudices;—that I shall, if possible, be even more utterly regardless of those biting criticisms which, inasmuch as the past is the mirror of the future, undoubtedly await me.

A question well put, is half answered. If this most sensible maxim had been borne in mind, the disputes as to the invention of the steam-engine could never have presented that aspect of acrimonious violence by which even to this day they have been characterised. But, by endeavouring to make out one sole inventor where it behoved to discriminate many, men have rashly thrown themselves into a strait whence there is no retreat. The watchmaker best informed as to the history of his art, would remain silent before one who should ask, in general terms, who was the inventor of watches; whereas he would find little difficulty in answering the question, if it was put separately with reference to the main-spring, the various forms of escapement, and the balance-wheel. So is it with the steam-engine; it now embodies many ideas of leading importance, but entirely distinct from each other, which may not have proceeded from one common source, and into the origin and date of which it is our duty carefully to examine.

If to have made any use at all of steam, were to give, as has been pretended, a title to figure in this history, the Arabians must be instanced first of all. For, from time immemorial, their principal food, the granulated paste [*la semoule*], which they call *couscoussou*, has been cooked by the action of steam,

in strainers placed over rude kettles.* Such an instance is amply sufficient to shew the utter absurdity of the principle which leads to it being mentioned.

Did our countryman Gerbert, the same who wore the tiara under the name of Sylvester II., acquire any stronger claims, when, about the middle of the tenth century,† he caused the pipes of the organ in Rheims Cathedral to sound by means of steam? I think not; in the instrument of the future Pope, I see a current of steam used in place of a current of common air, and the

* We find the following account of a similar process among some of the natives of India, in Manetti, "Memoria delle diverse specie di Frumento e di Pane," Venezia, 1766. "Alcuni tra gl' Indiani lo [Riso] cuocono per mezzo del solo vapore dell' acqua bollente, ponendolo sopra un coperchio di pentola, o di paiolo traforato a foggia di vaglio, acciocchè da essi fori passi comodamente il vapore dell' acqua bollente sottoposta, ed i granelli del Riso si cuochino perfettamente senza rompersi." p. 163.—Tr.

† M. Arago says, "vers le milieu du IX^e^ siècle;" but Gerbert was raised to be Archbishop of Rheims by his former pupil, Robert King of France (son of Hugh Capet), who began his reign in 997. He was soon after translated to the Archbishopric of Ravenna, by Otho III., Emperor of Germany, who had also been his pupil. And, by the influence of this monarch, he was created Pope, with the title of Silvester II. in 999. He died in 1003.

Geber, the famous Arabian philosopher, called by the Arabians *Giaber*, flourished at the time which M. Arago assigns to Gerbert. See D'Herbelot, Bibliotheque Orientale, *voce* Giaber.

The instance of mechanical ingenuity mentioned in the text, is thus recorded by William of Malmesbury, along with other still more marvellous feats of the same distinguished person. "Extant apud illam ecclesiam [Rhemensem] doctrinae ipsius documenta, horologium arte mechanica compositum, organa hydraulica, ubi mirum in modum, per aquae calefactae violentiam, ventus emergens implet concavitatem barbiti, et per multiforatiles transitus aereae fistulae modulatos clamores emittunt." Willielm. Malmesbur. de gestis Regum Anglorum, Lib. ii. inter Rer. Anglic. Script. ed. Lond. 1596, fol. 36, verso.—Tr.

musical phenomenon of the organ-pipes produced; but in no-wise a mechanical effect, properly so called.

The first instance of motion produced by means of steam, I find in a toy of even greater antiquity than Gerbert's organ; viz. in an æolipile of Hero of Alexandria,* the date of which is so far back as

* The author of the ΠΝΕΥΜΑΤΙΚΑ, or *Spiritalia*, a curious treatise, which, along with his other works, is to be found in the Mathematici Veteres, Gr. et Lat. Par. 1693, fol.

Æolipile, a word which has been spelt by different writers in an infinite variety of ways, is simply *Æoli-pila*, or ball of Æolus. The machine itself has been constructed of several forms, and has often served purposes of ingenious amusement. In point of practical utility, it has been employed instead of bellows, directing a strong current of steam on the fire, in place of a blast of air. Sir Hugh Plat, at p. 23 of his "Jewel House of Art and Nature," (printed at London in 1653), gives a particular description of one which he calls "A round ball of copper or Latten, that will blow the fire very strongly, onely by the attenuation of water into air; which device may also serve to perfume with;" and he annexes a wood-cut of it.

But the most singular details as to an instrument of this sort with which we have met, are given in the following passage, taken from Plot's Staffordshire. "Yet there are many old customs in use within memory, of whose originals I could find no tolerable account, that possibly might commence as high as these times; such as the service due from the Lord of Essington in this county [Stafford] to the Lord of Hilton, about a mile distant, viz. that the Lord of the manor of Essington shall bring a goose every New-year's-day, and drive it round the fire in the hall at Hilton, at lest three times, (which he is bound to doe as mean lord) whil'st *Jack* of *Hilton* is blowing the fire. Now, *Jack* of *Hilton* is a little hollow image of brass of about 12 inches high, kneeling upon his left knee, and holding his right hand upon his head, * * * having a little hole in the place of the mouth, about the bigness of a great pin's head, and another in the back about $\frac{2}{3}$ of an inch diameter, at which last hole it is fill'd with water, it holding about 4 pints and $\frac{1}{4}$, which, when set to a strong fire, evaporates after the same manner as in an æolipile, and vents it self at the smaller hole at the mouth in a constant blast, blowing the fire so strongly that it is very audible, and makes a sensible impression in that part of the fire where the blast lights, as I found by experience, May the 26th, 1680." Nat. Hist. of Staf-

a hundred and twenty years before our era. It may be difficult, without the aid of any diagram, to give a clear idea of the way in which this little apparatus acts; I shall, however, attempt it.

When a gas escapes, in one direction, from the vessel in which it is contained, that vessel, by a reaction, has a tendency to move in the direction diametrically opposite. The recoil of a gun charged with gunpowder, is neither more nor less than this; the gases generated by the combustion of the saltpetre, the charcoal, and the sulphur, rush through the air in the same line as the gun-barrel; the line of the barrel, prolonged backwards, terminates at the shoulder of the person who has fired; it is, then, on his shoulder that the violent reaction of the but-end takes effect. To change the line of the recoil, all that is necessary is to make the stream of gas issue in another direction. If the gun-barrel were plugged at its mouth, and perforated only by a horizontal lateral opening, perpendicular to its direction, the gas of the gunpowder would escape laterally and horizontally; the recoil would take effect at right angles to the gun-barrel, and would be felt on the arms, not on the shoulder. In the former case, the recoil struck the person who fired, from the front, as if to knock him over backwards; in the latter, its tendency would be to make him whirl round on his own axis. Let the gun-barrel then be fastened immoveably, and

fordshire, by Robert Plot, LL.D., p. 433, edit. Oxford 1686. At plate xxxiii. of that work there is an engraved likeness of *Jack*, to which we refer those of our readers who are curious in such matters.—Tr.

in a horizontal position, to a moveable vertical axis, and, at the instant of firing, it will more or less change its direction, and will cause this axis to revolve.

Preserving the same arrangement, let us suppose that this vertical rotatory axis is hollow, but closed at the upper end; that it terminates below, like a kind of chimney, in a boiler in which steam is generated; that there exists, besides, a free lateral communication between the interior of this axis and the interior of the gun-barrel, so that, after having filled the axis, the steam penetrates into the barrel, and escapes from it by its horizontal opening. If we except the different degree of impetuosity, this steam, as it escapes, will act precisely as the gases disengaged from the powder in the gun-barrel plugged at its extremity, and perforated laterally; excepting that you will not here have only a single shock, as in the case of the sharp and instantaneous discharge of the gun; on the contrary, the rotatory motion will be, like the cause which produces it, uniform and continuous.

In place of a single gun-barrel, or rather in place of a single horizontal tube, let several be adapted to the vertical rotatory tube, and we shall have, with merely some unimportant variations, the ingenious apparatus of Hero of Alexandria.

Here, unquestionably, is a machine in which steam generates motion, and is capable of producing mechanical effects of some importance;—here is a real steam-engine. Let me hasten to add, that in no particular does it really coincide, either

in its form, or in the mode in which the moving-power acts, with the steam-engines now in use. If ever the reaction of a current of steam should become useful in practice, it would, beyond all doubt, be necessary to refer the original idea of it to Hero; at the present day, the rotatory æolipile can be mentioned here only as wood-engraving would be in the history of printing.*

In the engines used in our manufactories, in our steam-boats, on our railroads, the motion is the direct result of the elasticity of steam. It becomes, then, important to enquire where and in what manner the notion of this force has had its origin.

The Greeks and Romans were not ignorant that steam is capable of acquiring a prodigious mechanical power. They went so far as to explain, by the

* These reflections apply equally to the plan which Branca, an Italian architect, published at Rome in 1629, in a work entitled "*Le Machine;*" and which consisted in producing a rotatory motion by directing the steam issuing from an æolipile, as a blast or current of wind, on the pinions of a wheel. If, contrary to all probability, steam should ever come to be used with advantage as a direct blast, Branca, or the author, now unknown, from whom he may have borrowed the idea, will take the first place in the history of this new kind of engine. As far as our present steam-engines are concerned, Branca has no real claims whatever.—M. Arago.

The complete title of Branca's work alluded to above, is as follows:—"Le Machine volume nuouo et di molto artificio da fare effetti marauigliosi tanto Spiritali quanto di Animale Operatione arichito di bellissime figure conle dichiarationi a ciascuna di esse in lingua nolgare et latina. Del Sig^r. Giovanni Branca, cittadino Romano. Ingegniero, et Architetto della S^ta. Casa di Loreto. All' Illustriss. Monsignor Tiberio Cenci Vescouo di Jesi. In Roma adistanza di Jacomo Manuci In Piazza Nauona. Con licentia de Superi^rl. per Jacomo Mascardi. M.DC.XXIX."—Tr.

help of the sudden conversion into steam of some great body of water, those frightful earthquakes which, in a few seconds, drive the ocean from its natural boundaries, overthrow from their very foundations the most solid monuments of human industry, cast up dangerous rocks in the midst of unfathomable seas, and raise lofty mountains in the very heart of continents.

Whatever may have been said about it, this theory of earthquakes does not necessarily suppose that its authors had turned their attention to calculations, or experiments, or accurate mensuration. No one at the present day is ignorant that at the instant of the red-hot metal passing into the earthen or stucco moulds used in a foundry, a few drops of moisture contained in these moulds are sufficient to produce dangerous explosions. Notwithstanding the progress of science, metal-founders at the present day do not always avoid these accidents. How, then, was it possible for the ancients to guard completely against them? While they were casting the thousands of statues which formed the splendid ornaments of the temples, the public squares, the gardens, the private dwelling-houses at Athens and Rome, accidents would necessarily happen; the workmen found out their immediate cause, while the philosophers, in obedience to the principle of generalisation, which was the distinguishing characteristic of their school of philosophy, discovered in them miniature, but faithful representations of the eruptions of Etna.

All this may be quite true, and yet be of no

importance whatever to the history which now engages our attention. I confess, indeed, that I have said even thus much on those slight delineations by ancient science of the powers of steam, only that I may, if possible, live at peace with the Daciers, of both sexes, and the Dutens of our days.*

Power, whether natural or artificial, before it is made of real use to man, has almost always been turned to the account of superstition. It will be seen that steam is no exception to the general rule.

Ancient history had informed us, that on the banks of the Weser, the god of the Teutones of old sometimes showed himself unpropitious by a sort of thunder-clap, immediately succeeded by a cloud

* From the same motive, I can hardly allow myself to omit here mentioning an anecdote which, through all that in it is romantic and contrary to our present knowledge of the mode in which steam operates, lets us see the high idea which the ancients formed of the power of this mechanical agent. It is related that Anthemius, Justinian's architect, had a dwelling-house adjoining that of Zeno, and that to play a trick upon that orator, his avowed enemy, he placed in the ground-floor of his own house several caldrons filled with water; that from a hole bored in the lid of each of these caldrons, a flexible tube was conducted to the partition wall, and fitted in under the beams which supported the ceilings, of Zeno's house. The result was, that these ceilings, the moment the fire was lighted beneath the caldrons, shook as if there had been a violent earthquake.—M. Arago.

For a minute and amusing narrative of this achievement of Anthemius, see Agathias, "de Imperio et rebus gestis Justiniani," Lib. v. In the folio Paris edition of 1660, it is to be found at pp. 150, 151. The principal part of the story of Agathias, and the testimony which Procopius (de Ædificiis) bears to the skill of Justinian's architect, are given in Gibbon's Roman Empire, Chap. xl.—Tr.

which filled the sacred enclosure. The statue of the god Busterich, discovered, it is said, in excavations, clearly shows the method by which the pretended miracle was effected.

The god was of metal; the head was hollow and contained an amphora* of water; wooden plugs closed up both the mouth and another opening above the forehead; live coals, dexterously placed in a cavity of the skull, gradually heated the liquid. Very soon, the steam generated forced out the plugs with a loud report; it then escaped with violence in two streams, and raised a thick cloud between the deity and his stupefied worshippers. It would appear that in the middle ages some monks found their account in this invention, and that the head of Busterich has performed its office before other than Teutonic multitudes.†

In order to fall in, after the first faint glimpses by the Greek philosophers, with any useful ideas on the properties of steam, we find ourselves compelled to pass over an interval of nearly twenty centuries. It is true, that then accurate, conclu-

* About nine English gallons.—Tr.

† Hero of Alexandria attributed the sounds which have been the subject of so much controversy, which the statue of Memnon emitted when struck by the rays of the rising sun, to the passage, through certain apertures, of a current of steam which the heat of the sun was supposed to produce from water; with which the Egyptian priests, it is said, supplied the interior of the pedestal of the statue. Solomon de Caus, Kircher, and others, have gone so far as to try to discover the particular contrivances, by means of which the cunning of priestcraft thus ensnared the imagination of the credulous; but every thing leads us to believe that their conjectures are not well founded, if, indeed, there is here any thing to be conjectured.—M. Arago.

sive, irresistible experiments, succeed to conjectures destitute of proof.

In 1605, for instance, we find Flurence Rivault,* a gentleman of the bed-chamber to Henry IV., and the preceptor of Louis XIII., discovering that a thick bomb-shell, containing water, is sure to explode when it is put in the fire after having been plugged ;—that is to say, when the steam is prevented from diffusing itself freely through the air in proportion as it is generated. The power of steam is here shown to be capable of a clear proof, which may to a certain extent be numerically estimated ; † but it also presents itself to us as a frightful instrument of destruction.

* The title of his book is, " Les Elemens de l'Artillerie, concernans tant la premiere inuention et theorie, que la practique du Canon. Par le Sieur de Flurance Rivavlt. A Paris chez Adrian Beys, ruë Sainct Jacques, ioignant la Rosse Blanche. M.DC.V."—Tr.

† If any learned person should object that I have not gone far enough back when I stop at Flurence Rivault; if he should adduce a quotation from Alberti, who wrote in 1411, to inform us that so early as the beginning of the fifteenth century, lime-burners greatly dreaded, for the safety both of their kilns and of themselves, the explosions of limestones within which there happens to be a cavity, I would reply that Alberti himself was ignorant of the real cause of those dreaded explosions ; that he attributed them to the action of the flame converting into vapour the air contained in the cavity ; and lastly, that a limestone accidentally hollow, would not have furnished any of the means of numerical calculation which the experiment of Rivault appears to admit of.—M. Arago.

The passage of Alberti in which these explosions and their cause are mentioned, is as follows :—" Si è trouato che nel mezo delle pietre, & massimo delle tonde, sono alcuna volta certe concauitati, nelle quali rinchiusa l'aria, arreca danni grandissimi : Percio che acceso il fuoco nella fornace, egli auiene mediante, ò il fuoco, ò pure il freddo, che và allo indentro, che essa aria si ristringa, ò pure che riscaldandosi finalmente essa pietra, la medesima aria si conuerta in

Some great minds, not satisfied with this uncomfortable reflection, conceived that mechanical powers, like human passions, must become advantageous, or hurtful, according as they are well or ill directed. In the particular instance of steam, there is, in fact, need only of the most simple artifice to apply to productive labour that formidable elastic power which, to all appearance, shakes the earth to its very foundations, surrounds the art of the metal-founder with real perils, and shatters into a thousand fragments the thickest bomb-shell!

In what state is this projectile before it explodes? Its lower part contains water, very hot, but still liquid; the remainder of the space is filled with steam; this latter, with the distinctive property of gaseous substances, presses equally in all directions, acting with the same degree of force on the water as on the metal case which contains it. If, at the lower part of this case, we place a cock, as soon as it is turned, the water, expelled by the steam, will rush out of it with extreme velocity. If the cock terminates in a tube, which, after being bent round the outside of the bomb, is pointed vertically upwards, the discharged water will ascend in it so much the higher as the steam is more elastic; or rather, for it is the same thing in other words, the water will rise the higher in proportion to the increase of its temperature. This ascending move-

vapore; Et è certo che egli rigonfia, & rompendo per ogni verso la prigione in cui si truoua, con scoppio, & impeto grandissimo sene esce, & disturba & manda sozzopra tutta la massa della fornace." L' Architettura di Leonbatista Alberti, Firenze. M.D.L. P. 56. l. 37. —Tr.

ment will meet with no limit but the strength of the sides of the apparatus.

If for the bomb-shell we substitute a thick metal boiler of a vast capacity, there is nothing to prevent our raising great bodies of liquid to indefinite heights, by the mere action of steam; and we shall thus have created, in every sense of the word, a steam-engine available as a pump.

You have now been made acquainted with the invention for which France and England have contended, as in times of yore seven cities of Greece, in their turn, arrogated to themselves the honour of having been the birth-place of Homer. On the other side of the Channel, all have concurred in attributing the merit of it to the Marquis of Worcester, of the illustrious house of Somerset; on this side of the strait, we maintain that it belongs to a humble engineer, almost altogether overlooked by biographers,* viz. Solomon

* So much so, that it has been questioned whether De Caus was really a native of France. The only guide to any certain knowledge of Solomon de Caus' life that we have been able to find, is the internal evidence of his own writings. From these it appears, that his principal works were published on the English side of the Channel, or, like those of Papin, "*beyond the Rhine;*" and it is sufficiently singular, that the distinguished patronage which he frequently and gratefully acknowledges, was conferred on him by the Royal Family of that country, which, in all that relates to mechanical science, seems then, as now, to have asserted a proud pre-eminence.

Solomon de Caus was, as he states in the dedication prefixed to the second Book of his "Raisons des Forces Mouvantes," for some time in the service of the Prince of Wales at Richmond. This was Prince Henry, (not Charles, as erroneously stated by Mr. Stuart in his "Anecdotes of Steam Engines," 1829,) son of James I., who died in 1612, and whose sister Elizabeth was married, three months

de Caus, who was born at Dieppe or in its neighbourhood. Let us take an impartial glance at the respective claims of these two competitors.

afterwards, to the Elector Palatine. Upon this event, De Caus went over to Heidelberg, where he became "Ingenieur et Architecte de son Altesse Palatine Electorale," and from this place most of his books are dated. The dedication above alluded to is, "A la Tres-illustre et Vertueuse Princesse Elizabeth, Princesse de la Grande Bretaigne, Electrice Palatine;" and in the preceding year, 1614, he dedicates another work, "Institution Harmonique," "A la Tres-illustre et Vertueuse Dame Anne, Royne de la Grande Bretaigne." In the "Beauties of England and Wales," it is stated, that, "Monsieur Solomon de Caus, Inigo Jones, and Webb, were successively engaged to enlarge and embellish" Wilton House, the famous seat of the Herberts, Earls of Pembroke, in Wiltshire. In the catalogue of the British Museum a book is ascribed to *Isaac* de Caus, called "Wilton Garden." This Isaac published a work of which one edition appeared in 1657, but another is without date, entitled, "Novvelle Invention de lever l'Eav plvs havlt que sa source, auec quelques Machines mouantes par le moyen de l'Eau et vn discours de la conduite d'yceelle, par Isaac de Cavs, Ingenyeur et Architecte, Natif de dieppe." In 1659, a translation of this, by John Leak, was published in London, in which exactly the same copper-plates are employed for illustration as in the original volume.

From their surname being the same, and from the great similarity of many of the mechanical contrivances which they invented or described, as well as from their both having apparently found professional employment in England, there seems reason to conclude that the two De Caus were in some way related to each other; and, if they were not brothers or cousins, but either father and son, or uncle and nephew, Isaac appears, from the smaller number of the mechanical contrivances which he has published, to have been the first in order of time, although this is not so stated in the usual biographical accounts. Mr. Stuart, in his "Anecdotes of Steam-Engines," seems to consider them to be the same person, under different names, (vol. i. p. 27.)

On the authority of the title-page to his work already cited, Isaac may be held to have been a native of Normandy. It is possible that the same authority may be the only one that has led his biographers to call Solomon also a Norman. M. Arago, in the Annuaire

The Marquis, being seriously implicated in the intrigues in the latter years of the reign of the Stuarts, was imprisoned in the Tower of London. One day, as the story goes, the lid of the pot in which his dinner was cooking, suddenly rose. What can a man do in such a case, but *think?* The Marquis, then, *thought* about the strange phenomenon he had just witnessed. Then it occurred to him that the same force which had lifted the lid, might become, in certain circumstances, a useful and convenient moving power; after regaining his liberty, he explained, in 1663, in a

du Bureau des Longitudes for 1830, only says that he was a Frenchman, without more minutely particularising the place of his birth. And the only arguments by which he supports even this general assertion are, 1. that he wrote in French, 2. that he calls himself, in a dedication to Louis XIII., a subject of that monarch, and, 3. that he is also styled his subject in the privilege granted to his publication. But these circumstances are consistent with the supposition of his having been French only by extraction, as he might, even in that case, take a pride in using the language of his fathers, and claiming his connection with their country and its sovereign, while in the privilege the designation which he adopts in the dedication is naturally repeated.

It may be worth observing, that Solomon de Caus' books printed at Frankfort were published "En la boutique de Jan Norton, *Libraire Anglois;*" and his first work, "La Perspective avec la Raison des Ombres et Miroirs," was published in *London* (1612.) He seems afterwards to have gone to Paris, at least in 1624 he published there, "La Pratiqve et Demonstration des Horloges Solaires," and a second edition of "Les Raisons des Forces Mouvantes."

It must not be supposed, from the above observations, that we intend to assert that Solomon de Caus was born in England; of this we have no proof; but the weight of proof as to his birth-place rests on the nation which has claimed the honour of his inventions, and the circumstances mentioned above seem to shew that on this point there is yet some room for doubt.—Tr.

book entitled "A Century of Inventions,"* the means by which he thought he could put his idea

* Mr. Stuart, in his "History of the Steam Engine," has erroneously stated (p. 12,) that the "Century of Inventions" was first printed in 1683; and this error he has not corrected in the second edition of his work. The full title of the Marquis of Worcester's little book is as follows:—"A Century of the Names and Scantlings of such Inventions as at present I can call to mind to have tried and perfected, which (my former Notes being lost,) I have, at the instance of a powerful Friend, endeavoured now, in the Year 1655, to set these down in such a way as may sufficiently instruct me to put any of them in practice.—*Artis & Naturæ proles.* London: Printed by J. Grismond, in the year 1663." This little book has been often reprinted; and, in 1825, it was edited, with historical and explanatory notes and twenty-four illustrative engravings, by Mr. Partington.

To the kindness of a friend we are indebted for the sight of a copy of the first edition of the "Century of Inventions," to which is appended a description of "a stupendious Water-commanding Engine, boundless for height, or quantity, requiring no external or even additional help or force, to be set or continued in motion, but what intrinsically is afforded from its own operation, nor yet the twentieth part thereof," &c. &c. It is introduced by a preface, and concludes with a Latin elogium and English panegyric, "composed, through duty and gratitude, by an ancient servant of his Lordship, (James Rollock,) who hath, for 40 years, been an eye-witness of his great ingenuity, indefatigable pains, and vast expenses *in perfecting, for public service,* not only this most stupendious Water-commanding Engine, but likewise several other rare, useful, and never formerly heard of mathematical conclusions, of which he hath owned a Century, and thereunto I refer you; though *this* alone were enough to eternalise his name to all ages and future times," &c. &c. An address to the King (Charles II.) follows the preface, and is signed, "Your Sacred Majestic's faithfully devoted and passionately affected, *useful if cherished,* Subject and Servant, Worcester." There is also inserted the Act of Parliament for a Water-commanding Engine, with a prohibition to all others to make use of the same for 99 years; one-tenth part of the profits being also directed to be paid into the Exchequer, and *a model* of the engine to be delivered by the Marquis to the Lord Treasurer, or Lords Commissioners for the Treasury, on or before the 29th September, 1663, to be by him or them put into the Exchequer and kept there.

The panegyric is headed, "A Panegyrick to the Right Honorable

into practice. These means are, in all their essential points, at least in so far as we can understand them, the bomb-shell half full of liquid, and the ascending vertical tube which I have just described.

The bomb-shell, the same tube, are engraved in

Edward Lord Marquess of Worcester, upon his stupendious and never sufficiently-commended Water-work." We insert it, because it is an additional argument for the Marquis having made not only a descriptive invention, but *an actual engine*, producing such effects as he mentions to have been attained.—

"I know mean subjects need a skilful pen,
To stretch their worth on Tenterhooks, but when
A Theme falls out so pregnant, who can chuse
But strain his vulgar Wit to prove a Muse?

"Come, fainting Pilgrim, lay here down thy pack;
And, while thou rests thy wearied limbs, look back
Upon this Pageant, the Emblеme of his mind,
Whose Art and Skill hath this our Age refined.

"Here little *David* curbs the Gyant's brood,
Small drops of Rain contend with *Noah's* flood;
One weighs a thousand coming down apace,
Weighs but himself when he hath run his race.

"The Heavens admire, the Centre stands amazed,
To see such Streams by so small Forces raised.—
Great is the Work, but greater is the Fame,
Of that great Peer, who did invent the same.

"What Force or Strength can do, is in his reach;
His long Experience, Costs and Charges teach:
What *Greeks* nor *Romans* e're could do, this day
Our noble Britain here hath found the way.

"If Ages past had bred you, we had seen
Your Glorio's current run a bigger stream;
But Art and Envy meeting face to face,
Like *France & Spain*, dispute who shall take place.

"None but Ignoble Minds love to detract
From th' honour due to such a noble act:
On then, that After-ages may relate
your Service done to Countrey, King, and State.

"And though that envious Spirits spit their gall,
Your Noble Deeds are so well known to all,
As if their malice should take from your Praise,
Your own deserts will crown your head with Bayes."

The Latin elogium is much to the same purpose, and is written, *mutatis mutandis*, much in the same style; it is entitled, "In admirandam magis quàm imitandam, aut ullis Encomiis satis prædicandam, illustrissimi Domini Marchionis *Vigorniæ* Machinam Hydraulicam Elogium;" and precedes the panegyric.—Tr.

"les Raisons des Forces Mouvantes,"* a work of Solomon de Caus. There, the idea is clearly, simply, and unpretendingly set forth. Its origin has nothing romantic; it is connected neither with the events of civil war, nor with a famed state prison, nor even with the rising of the lid of a prisoner's pot; but, what is of infinitely greater importance in a question as to priority, it is, by the date of its publication, forty-eight years earlier than the "Century of Inventions," and forty-one years prior to the imprisonment of the Marquis of Worcester.

The dispute, thus made to depend on a comparison of dates, seemed to be of necessity brought to a close. For how, in fact, could it ever be maintained, that the year 1615 was not earlier than the year 1663? But those whose chief aim appears to have been to expunge every French name from this important chapter in the history of science, suddenly changed their ground as soon as "Les Raisons des Forces Mouvantes" had been extricated from the dusty libraries in which it lay buried.† They broke without hesitation their

* The title of the first edition of this work is as follows:—"Les Raisons des Forces Mouvantes, auec diuerses Machines tant utilles que plaisantes, Aus quelles sont adioints plusieurs desseings de grotes et fontaines, par Salomon de Caus, Ingenieur et Architecte de son Altesse Palatine Electorale. A Francfort, en la boutique de Jan Norton, 1615."—Tr.

† M. Arago seems here to imply too sweeping a censure on the English writers on the steam-engine. Although the work of Solomon de Caus, spoken of in the text, appears not to have been known to Professor Robison; yet full justice has been done to his claims by Stuart and Farey at least, if not by other English authors.—Tr.

former idol; the Marquis of Worcester was sacrificed to the desire of demolishing the claims of Solomon de Caus; the bomb placed on live coals, and its ascending tube, then ceased to be the true germ of the present steam-engine.

For my own part, I could never bring myself to allow that that man had done no good service, who, meditating on the enormous expansive power of water heated to a high temperature, was the first to see that it might be made available for raising great bodies of that fluid to any conceivable height. I cannot admit that no grateful remembrances are due to that engineer who was also the first to describe a machine fitted to realize such effects. Let us not forget, that we can judge fairly of the merits of an invention only by imagining ourselves carried back to the time when it was first made, and by putting out of our thoughts, for the time, all the information which has been added during the ages posterior to the date of that invention. Let us figure to ourselves one of the ancient mechanicians, Archimedes, for example, consulted as to the means of raising to a great height the water contained in a vast close metal receiver. He would, certainly, speak of huge levers,—of simple and block pullies,—of cranes,—perhaps of his ingenious screw; but how great would be his surprise, if any one were to solve the problem by the aid merely of a faggot and match! I ask, then, can any one dare to refuse the title of an invention, to a process at which the immortal author of the first and true principles of statics and hydro-

statics would have been amazed? The apparatus of Solomon de Caus, that metal shell in which a moving power almost indefinitely great is generated by means of a faggot and match, will always make a noble figure in the annals of the Steam-Engine.*

It is very doubtful if Solomon de Caus and the Marquis of Worcester ever executed their apparatus.† This honour is due to an Englishman,

* It has been asserted in a printed work, that J. B. Porta had given, in 1606, in his "*Spiritali*," nine or ten years before the publication of the work of Solomon de Caus, the description of an engine intended to raise water by means of the elasticity of steam. I have shewn elsewhere that the Neapolitan philosopher spoke neither directly nor indirectly of any engine in the passage referred to; that he aimed only at determining experimentally the relative volumes of water and steam; that in the little philosophical apparatus employed for that purpose, the steam could not raise the liquid, to use the author's own words, more than a small number of centimètres, or a few inches; that throughout the whole description of the experiment there is not a single word which implies that Porta was aware of the power of this agent, and the possibility of applying it to the construction of a practical working engine.

It may be thought that I ought to have mentioned Porta, were it only because of his researches as to the conversion of water into steam; but I would, in that case, beg to observe, that the phenomenon had already been attentively studied by Professor Besson of Orleans, towards the middle of the sixteenth century; and that in one in particular of the treatises of that mechanician, published in 1569, there is an attempt to determine the relative bulk of water and steam.—M. Arago.

The work of Porta to which M. Arago alludes, was first published at Naples in 1601, under the title of "Pneumaticorum libri tres; cum duobus libris curvilineorum elementorum." 4to. It was translated into Italian, and published, also at Naples, with the title, "I tre libri de' Spiritali," 1606, 4to.—Tr.

† We are not aware that it has ever been maintained that De Caus executed *his* apparatus. But Mr. Stuart, in his "Anecdotes of Steam-Engines," infers from a prayer of the Marquis which he quotes, and from some correspondence of the Marchioness, that the

Captain Savery. I class the machine which that

Great Machine was then in existence. In corroboration of this, he quotes from the translation of the Travels in England of Cosmo de Medicis, Grand Duke of Tuscany, published in 1821, (Mr. Stuart says, 1818,) that " on the 28th May 1699, his Highness saw at Vauxhall, an hydraulic machine, invented by my Lord Somerset, Marquess of Worcester. It raises water more than forty geometrical feet, by the power of one man only ; and in a very short space of time will draw up four vessels of water, through a tube or channel not more than a span in width." Mr. Stuart thinks it clear, from different reasons which he assigns, that this hydraulic machine must have been some sort of steam-engine ; and, from the remarkable coincidence of the description with that given by the Marquis, of the effects of his engine, probably the very identical " most stupenduous water-commanding engine."

It is but fair to observe, that this author has elsewhere publicly defended a totally opposite conclusion. In his " History of the Steam-Engine," he says that the " Century of inventions" is called by Walpole, *with much truth*, " *an amazing piece of folly ;*" and he has no mercy on " *the overwhelming quackery* of the Marquis of Worcester, and *the absurd extravagance of his pretensions.*" This inconsistency is perhaps not surprising in a writer whose statements are frequently not to be depended on. We have no desire to occupy our pages with an enumeration of the many palpable mistakes which occur in his works; but the present instance adds another to those which we have felt ourselves compelled to notice.

If Mr. Stuart had been accurate in his quotation, the Vauxhall machine might possibly have been one of Savery's engines, some of which, as mentioned below, were erected before 1698, when their inventor obtained his patent. But the year of Cosmo's visit to England was not 1699, but 1669 ; and the argument for the Marquis' claims is greatly strengthened by the correction of this most material error. The two accounts of the performances of the engine, the one by the Marquis, and the other by the Duke, or his secretary (the celebrated Magalotti), who wrote the Journal, are, in the essential point of numerical appreciation of the power, almost *verbatim* the same ; and it is not improbable that to ensure greater accuracy, the one might be *copied from the other*. This, however, we have been led to imagine solely from their extraordinary similarity, and from our not having met with a description of the Marquis' engine in any other contemporary work. Desaguliers, who

engineer made in 1698,* along with those of his two predecessors, although he introduced into it some essential modifications ; among others, that of forming the steam in a separate vessel. If it matters little, in so far as the principle is concerned, whether the steam, which is to be the moving power, is generated from the water which is to be raised, and within the same boiler where it is to operate, or whether it is made in a separate vessel, and, by means of a connecting tube with a cock, is admitted at pleasure above the water which it is required to discharge ; it certainly is not the same in a practical point of view. Another change of still more importance, well worthy of being specially mentioned, and of which the credit is equally due to Savery, will find a more appropriate place in the section which I shall immediately devote to the labours of Papin and Newcomen.†

has shewn every wish to detract from the reputation of Savery, was evidently not aware of any grounds for believing the Marquis to have constructed an engine, excepting the words of the noble inventor himself.—Tr.

* Mr. Robert Stuart, at p. 34 of his "History of the steam-engine," published in 1824, says, quoting from Robison, "The fact is, Savery obtained his patent in 1698, after a hearing of objections ; * * but, besides this, he had erected several of his engines *before* he obtained his patent ;" "and," continues Mr. Stuart, "published an account of his engine in 1696, under the title of *The Miner's Friend*, and *a Dialogue* by way of answer to the objections which had been made against it, in 1699 ; both were printed in one volume in 1702." We have not seen the publication of 1696 ; but we observe that in that of 1702, he says he worked a small model before some members of the Royal Society, on the 14th of June 1699.—Tr.

† We do not find, however, that further mention is made under the head referred to, of any other improvements by Savery. But the fact is, that Savery's engine consisted of *two* distinct *principles :*

Savery had entitled his work "The Miner's

raising water, in the first place, by the pressure of the atmosphere forcing it into a vacuum formed by the *condensation of steam;* and, in the second, by *the expansive power of steam.* The steam from the *detached* boiler was let into a vessel called a receiver, and, having driven out the air, was condensed by the affusion of cold water, and a partial vacuum formed. A communication being then opened with a suction pipe, twenty-four feet in height, the lower end of which was placed in a cistern or reservoir of water, that water was forced upwards, by the pressure of the atmosphere, into the receiver. When this was nearly filled, the communication with the suction-pipe was shut off, the steam was re-admitted into the receiver, and by its expansive power forced the water contained in it up an ascending, or, as he called it, a force-pipe. This second operation is similar to that indicated by Solomon de Caus, and not only indicated, but perhaps practised by the Marquis of Worcester. The prior operation,—that of raising the water into a vacuum formed by the condensation of steam,—we believe to have been *original* with Savery. For although Papin had described the principle in the "Acta Eruditorum" of Leipzig for 1690, and in a French work published five years later at Cassel, he applied it in a different manner; and there is no proof, or even surmise, of its having been known to Savery when he invented his engine in 1696, or perhaps sooner. Indeed, Papin, with praiseworthy candour, as quoted by Belidor, Arch. Hyd. Tome ii. p. 309, writes, "What I say here is not to give room for believing, that Mr. Savery, who has since published this invention at London, is not actually the inventor. I do not doubt that the same thought may have occurred to him, as well as to others, without having learnt it elsewhere." When we consider the whole of the contrivances invented by Savery, as described by himself in "The Miner's Friend," we cannot but accord him the praise of very great ingenuity, independent of the merit of having made THE FIRST WORKING STEAM-ENGINE, (if he was not preceded in that by the Marquis of Worcester); but at all events, of having been the first who introduced it into use. His drawing and description in "The Miner's Friend," apply to an engine with two receivers; but it was soon altered, in practice, to one receiver, as we have described it.

Switzer, in his System of Hydrostatics and Hydraulics, published in 1729, says, p. 325, "Among the several engines which have been contrived for the raising of water for the supply of houses and gardens, none has been more justly surprising than that for the raising

Friend."* The miners shewed themselves but little sensible of the compliment. With but one exception, none of them ordered his engines. They have been employed only for supplying water to various parts of palaces, pleasure-houses, parks, and gardens; recourse having been had to them only when the difference of level to be surmounted did not exceed twelve or fifteen metres.† It must, besides, be confessed, that the danger of explosions would have been very great, if this apparatus had been possessed of the prodigious power which its inventor professed to have gained.

Whatever imperfection the practical success of Savery displays, the name of this engineer deserves

of water by fire, the particular contrivance and sole invention of a gentleman with whom I had the honour long since to be well acquainted; I mean the ingenious Captain Savery, some time since deceased, but then a most noted engineer, and one of the Commissioners of the sick and wounded.

"It was a considerable time before this curious person, who has been so great an honour to his country, could (as he himself tells us,) bring this his design to perfection, on account of the awkwardness of the workmen who were necessarily to be employed in the affair; but at last he conquered all difficulties, and procured a recommendation of it from the Royal Society, in Trans. No. 252, and soon after, a patent from the Crown, for the sole making this engine. And I have heard him say myself, that the very first time he played, it was in a potter's house at Lambeth, where, though it was a small engine, it forced its way through the roof."—Tr.

* The full title of Savery's book is as follows:—"The Miner's Friend, or an Engine to raise Water by Fire described, and the Manner of Fixing it in Mines, with an Account of the several other uses it is applicable unto; and an Answer to the objections made against it. By Tho. Savery, Gent. *Pigri est ingenii contentum esse his quæ ab aliis inventa sunt. Seneca.* London, printed by S. Crouch at the corner of Pope's-head Alley in Cornhill. 1702."—Tr.

† A Metre is 3·2808992 English feet.—Tr.

to occupy a most distinguished place in the history of the steam-engine. Persons whose whole life has been devoted to speculative labours, are not aware how great is the distance between a scheme, apparently the best concerted, and its realisation. It is not that I hold, with a celebrated German philosopher, that Nature always cries "No, no!" when we attempt to raise a corner of the veil which hides her; but, to follow out the same metaphor, it is at least fair to affirm, that the enterprize becomes more difficult, more delicate, and of more doubtful success, in proportion as it demands both the concurrence of more artists, and the employment of a greater number of material elements; and, as to these various points, making allowance for the period at which he lived, was there ever a man placed in more unfavourable circumstances than Savery?*

* Little appears to be known of the life of Savery; and an enquiry made some years ago of a gentleman of the same name at Bristol, who acknowledged relationship, did not procure any information or papers.

He published a small pamphlet, entitled "Navigation improved, or the Art of Rowing Ships of all rates in Calms, &c.; by Tho^s Savery, Gent. London. Printed and sold by James Moxon, at the Atlas in Warwick Lane, 1698." He says he had had a patent for it about two years, and that it had been worked upon the Thames. The engine, as he calls it, consisted of two paddle-wheels, one on each side of the ship, connected by a shaft above the deck, and worked there by a capstan.

This, however, was not original, for he refers in the pamphlet to an objection taken against it by Mr. Dummer, the surveyor of the navy, "that it was the same sort of engine that was used in the year 1682 at Chatham, for the towing of ships, the charge of which proved a loss to the Crown." This most probably was the vessel made under the direction of Prince Rupert, having paddle-wheels worked by horses; and which, in a trial on the Thames, witnessed

I have hitherto spoken only of steam-engines whose resemblance to those which at present bear that name, may be more or less disputed. I now proceed to enquire into the steam-engine of modern times; that one which is used in our manufactories, in our steam-boats, at the entrance to the shaft of almost every mine. We shall behold its birth, its increase, and its developement; proceeding sometimes from the inspirations of a few superior minds, sometimes from the goading of necessity;—for necessity is the mother of invention.

The first name which will come before us in this new epoch, is that of Denis Papin. It is Papin whom France will have to thank for the honourable place which she can claim for herself in the history of the steam-engine. Yet the very just pride which his success may well teach us to feel, will not be

by Papin, beat the King's Barge manned by sixteen rowers. Indeed, there appear to have been about that time several projects of the same kind. M. Duquet is cited as having made similar experiments in France in 1693.

We find a similar invention described by William Bourne in 1578, in a book called "Inventions or Deuises; very necessary for all Generalles and Captaines, or Leaders of Men, as well by sea as by land." There is still an older authority for this application of the paddle-wheel, which we do not suspect Savery of knowing any thing of, both on account of the language in which it is written, (for the Captain, in spite of the Latin motto prefixed to his "Miner's Friend," does not appear to have been as well versed in literature as he was ingenious in science,) and of its being an old and rather scarce book; "Robertus Valturius de re Militari," folio. "Johannes ex Verona oriundus, cyrurgi medici filius, artis impressorii magister, hunc de re militari librum elegantissimum; litteris et figuratis signis, sua in patria primus expressit, An. MCCCCLXXII." See the description and engraving given therein at p. 210. In the above, the *editio princeps*, the numbers of the pages are not printed, but have been added, in the copy which we have seen, in MS.—Tr.

altogether unmixed. We shall find that the claims of our countryman occupy a place only in the records of foreign lands;* that his principal works were published beyond the Rhine; that his liberty was menaced by the revocation of the Edict of Nantes; that it was in a sorrowful exile that he enjoyed, for a brief period, that blessing which studious men most anxiously desire,—tranquillity of mind! Let us hasten to cast a veil over these miserable results of our civil broils; let us forget that fanaticism assailed the religious tenets of the philosopher of Blois; and let us return to mechanics. Here, at least, the orthodoxy of Papin has never been questioned.

In every machine there are two things to be considered; on the one hand, the moving power; on the other, the combination, more or less complicated, of parts both fixed and moveable, by the help of which this power communicates its action to the resistance. At the stage which mechanical science has now reached, the success of a machine intended to produce great effects depends chiefly on the nature of the moving power, on the way in

* That ingenious philosopher and mechanician, Denis, or rather, we believe, Denys Papin, has been chiefly known in England by his *digester*, described by him in the following work:—"A new Digester or Engine for softening bones, containing the description of its make and use in these particulars:—viz. Cookery, Voyages at sea, Confectionary, Making of Drinks, Chymistry, and Dying. With an account of the Price a good big Engine will cost, and of the Profit it will afford. By Denys Papin, M.D., Fellow of the Royal Society. London, printed for Henry Bonwicke at the Red Lyon in St. Paul's Churchyard. 1681." It was printed by an order of the Council of the Royal Society, of 8th December 1680, (Signed) Cur. Wren.—Tr.

which it is applied, and its force regulated. And so it was to produce an economical moving power, capable of making the piston of a large cylinder move incessantly upwards and downwards with great force, that Papin devoted his life. Thereafter to borrow from the strokes of the piston the power necessary in order to turn the stones of a flour-mill,—the rollers of a flatting-machine,—the paddles of a steam-boat,—the bobbins of a thread manufactory;—to raise the ponderous hammer which strikes redoubled blows on enormous balls of red-hot iron, as they come from the reverberating furnace;—to cut with the jaws of the shears thick bars of metal, as with finely sharpened scissors we clip a ribbon; these are all, I again repeat, problems of a very secondary kind, and in which the most ordinary engineer would find no difficulty.*

* Nor need Papin have had any difficulty in enumerating all these applications of a moving-power, as he may have found them, and many more, ready stated to his hand in a book published in London in 1651, entitled, "Invention of Engines of Motion lately brought to perfection; whereby may be despatched any work now done in England, or elsewhere, (especially works that require strength and swiftness,) either by wind, water, cattel, or men, and that with better accommodation and more profit than by any thing hitherto known and used." This is in the form of a letter to Hartlib, author of a celebrated Discourse on Flanders Husbandry, and many other agricultural works. The unknown author of the "Engines of Motion," says, "I have already erected one little engine, or great model, at Lambeth." See Stuart's Anecdotes of Steam-Engines, pp. 77-79, where it is suggested that the author may have been the Marquis of Worcester.

The problems alluded to in the text have exercised the ingenuity of the most eminent engineers for upwards of a century and a half; and without their solution no mechanical power, however great, could be deemed of very much use to the world. The per-

Let us, therefore, attend exclusively to the means by the aid of which Papin proposed to produce the reciprocating motion.

Suppose a large upright cylinder, open at the top, and resting, at its base, on a plate of metal, perforated by a hole, which can be shut and opened at pleasure by means of a cock.

Introduce into this cylinder a piston, that is to say, a circular plate, full, and moveable, fitting nicely. The atmosphere will press with all its weight on the upper surface of this kind of diaphragm, and will force it downwards. That portion of the atmosphere which occupies the lower part of the cylinder will have a tendency, by its reaction, to produce the contrary motion. This second force will be equal to the first, if the cock is open, because gases press equally in all directions. The piston will thus be propelled by two opposite and equal forces; it will, notwithstanding, descend, but only in virtue of its own gravity. A counterpoise, a little heavier than the piston, will, on the other hand, be sufficient to bring it to the top of the cylinder, and to keep it there. Let us suppose that the piston has reached this extreme

fection in all kinds of mechanism of which our country now can boast, has not been attained without incessant and most praiseworthy exertion; and it is melancholy to consider how many persons, respectable alike for their talents and character, have sunk under the difficulty of contriving those practical applications which M. Arago, himself most honourably distinguished in theoretical research, considers as having been made with so much facility. For, alas! "persons whose whole life has been devoted to speculative labours, are not aware how great is the distance between a scheme, apparently the best concerted, and its realisation." See above, p. 44.—Tr.

point, and endeavour to discover a method of making it descend with great force, and then re-ascend.

Let us suppose that after having shut the lower cock, we can suddenly annihilate all the air contained in the cylinder; in a word, that we can make there a vacuum. The vacuum once made, the piston, being subjected to no pressure but that of the external air from above, will rapidly descend. This movement being completed, let the cock be opened; the air will immediately return below, to counterbalance the action of the atmosphere above; again, as at first, the counterpoise will raise the piston to the top of the cylinder, and all the parts of the apparatus will return to their first state. A second exhaustion, or, if you prefer it, a second annihilation of the air within, will make the piston descend anew, and so on.

The real moving power of the system would, in this case, be the pressure of the atmosphere. Let me hasten to undeceive those who may think they discover, in the ease with which we walk and even run through air, an indication of the weakness of such a moving power. With a cylinder, two metres in diameter, the force which the piston of the pump would exert in descending, the weight which it could raise at each of its strokes, the whole height of the cylinder, would be 31,000 kilograms, or 600 quintals, old measure. This enormous power, frequently repeated, would be obtained by means of a very simple apparatus, if we could discover an expeditious and economical method of

generating and destroying, at pleasure, an atmospheric pressure in a metal cylinder.

This problem Papin has solved. His grand and beautiful solution consists in substituting an atmosphere of steam for the atmosphere of common air; in replacing this latter by a gas which, at 100° centigrade, has precisely the same elastic force, but which has, in addition, this important advantage, which is not possessed by the ordinary atmosphere, viz. that the force of the aqueous gas very rapidly diminishes when the temperature is lowered, and that it even ends at last by disappearing almost entirely, if the cooling down has been carried far enough.* I might very well and more shortly

* The claims of Denys Papin to the invention of creating a vacuum by the condensation of steam, are stated by M. Arago in the *Annuaire* for 1830, to have been recorded by Papin himself in a Memoir in the Acta Eruditorum Lipsiæ for 1690; and again in a Collection of his works on machines, printed at Cassel in 1695. Belidor gives him the priority in his "Architecture Hydraulique," tome ii. p. 308, printed in 1739; but his claims appear to have been nearly forgotten when they were urged by the eminent French mathematician Bossut, in his "Hydrodynamique," of which the first edition was published in 1771, and the second in 1796. They were disputed by Dr. Robison in his article Steam Engines, in the Encyc. Brit. in 1811, probably taking Belidor as his authority, who, in the page above referred to, quotes for the origin of the invention, a work of Papin's entitled "Nouvelle maniere d'elever l'eau par la force du feu," printed at Cassel in 1707. We have no doubt that Dr. Robison, relying on Belidor, pushed his enquiries no further.

This, however, was set right by Stuart and by Farey, in their respective Histories of the Steam-Engine, published in 1824 and 1827. But Papin's most able advocate has been M. Arago, who entered into the detail of his publications and schemes in the *Annuaire* for 1830. We greatly wish that that gentleman, or some other learned countryman of Papin, would give to the world a

characterise Papin's discovery, by saying that his

collected edition of all his works. We have not had an opportunity of referring to the greater part of them.

The few years which preceded Papin, about the middle of the seventeenth century, form a most brilliant era in the history of discoveries in natural philosophy.

Galileo, in 1640-41, surmised the true nature of a vacuum, and of the pressure of the atmosphere. His pupil Torricelli, pursuing the subject after his death, invented the barometer, and proved the theory in 1643. Pascal hearing of it, as he says, at Rouen, published, in 1647, his "Nouvelles Experiences touchant le Vuide;" confirming the deductions of the Italian philosophers; and he caused to be made, in 1648, the memorable experiment of the Puy de Dome, thereby establishing the variation in the pressure of the atmosphere at different heights, which Descartes had before conjectured:—"Ce qui nous ravit tous," says M. Perier, who, at Pascal's request, made the experiment—in speaking of the phenomenon observed in it, "d'admiration et d'étonnement." He further developed the theory, in 1653, by many experiments, which were not published until 1663, a year subsequent to his death, in his "Traitez de l'Equilibre des Liqueurs et de la Pesanteur de la Masse de l'Air."

Otto de Guericke had in the meantime applied himself to the same subject, and invented an air-pump, the effects of which he exhibited to the assembled German Princes at the Diet of Ratisbon in 1654, the account of which was published by Gaspar Schottus, in his "Technica Curiosa," Norimb. 1664. 4to. Robert Boyle passed some time at Florence in 1642, in which year Galileo died at a neighbouring village; he published, in 1660, "New Experiments upon the spring of Air," and described therein an air-pump he had invented two or three years before, and which had been improved by Hooke. The experiments of the Academia del Cimento, which are very full upon this subject, were published at Florence in 1666. Otto Guericke did not himself publish until a later period. His work entitled "Experimenta nova Magdeburgica de vacuo spatio, &c." Amst. 1672, is now before us, and looking to his chapters 27 and 28 of lib. II., and his Iconismi XIV. XV. where he describes and delineates a cylinder with a packed piston and rod, and states his mode of forming a vacuum, by extracting the air under the piston by means of his air-pump, and thus producing a power for raising weights by the pressure of the atmosphere, we observe a great similarity to the apparatus in which Papin, several years later, when residing at Marburg, formed his vacuum by the condensation of steam. In-

object was to employ steam for producing a vacuum

deed, we think it pretty apparent, that the Professor of Marburg not only borrowed the apparatus, but took the novel idea of using the pressure of the atmosphere *as a power*, from the far-famed burgomaster of Magdeburg. Germany thus claims a share in the invention of THE GREAT MACHINE, as it is called, by just anticipation, in the correspondence between the Marchioness of Worcester and her confessor.

Belidor, quoting from the work of Papin in 1707, says that "from the year 1698, he had made a number of experiments by desire of the Landgrave Charles of Hesse Cassel, to raise water by fire, which he had communicated to divers persons, and among others, to Leibnitz, who answered that he also had entertained the same idea.

"This work having been interrupted," continues Papin, "would perhaps have been forgotten, had not Leibnitz, in a letter of 6th January 1705, done me the honour to ask my opinion of the machine of Mr. Thomas Savery, of which he sent me the print made in London. Although its construction was a little different from ours, and I had not the description sent me, I saw at once that the English machine and that of Cassel were founded upon the same principle, as I shewed to the Landgrave; which caused his Highness to resume the design of pushing on this invention, which, without doubt, is a very useful one, as will be seen hereafter. I can then testify, that it has cost much time, labour, and expense, to bring it to its present state of perfection. It would be tedious to particularise all the unforeseen difficulties met with, and all the trials which have turned out contrary to expectation; and, therefore, I shall limit myself to making known how far what we now have, is preferable to what we had done at first, and to what Mr. Savery has since done, that the public may not be under any mistake in the choice of these different machines, and may profit, without trouble, by what has proved so expensive; and likewise, that they may see that their obligation to his Highness is not solely for having formed the first plan, but for having overcome the difficulties of the first execution, and brought matters to their present state of perfection."

Belidor, after this long quotation, goes on to observe—"M. Papin then gives the description of the machine he had executed, and forgets nothing to give it value. *But whatever he may say, it is very far from being equally ingenious and complete with that of Mr. Savery*, which possesses the advantage of having within itself all the movements it requires, without any one touching it; whereas, the other cannot act without the help of several men, one of whom at least is

in a great space, and that this method is, besides, both expeditious and economical.*

The machine in which our illustrious countryman was thus the first to combine the elastic force of steam with the property which it possesses of being annihilated when it is cooled down, he never constructed on a great scale. His experiments were always made upon mere models. The water from which the steam was to be supplied, did not even occupy a separate boiler; contained in the cylinder, it rested on the metallic plate which closed its lower extremity. It was this plate which Papin heated directly, to convert the water into steam; it was from the same plate that he removed the fire, when he wished to effect the condensation. Such a process, scarcely tolerable in an experiment intended to verify the accuracy of a principle, would evidently be out of the question if it were necessary to make the piston move with

required to give his work uninterruptedly, with contrivances *which render this machine as imperfect as that of Mr. Savery is complete.*" It does not, in fact, appear that the engine improved by Papin, after he was made acquainted with Savery's engine, was ever brought into practical use.—Tr.

* An English engineer, deceived, no doubt, by some inaccurate translation, lately pretended that the notion of employing steam in the same engine, both as an elastic force and as a means of rapidly producing a vacuum, originated with Hero. But I, for my part, have indisputably proved that the Alexandrian mechanician never even thought about the steam; that in his apparatus the alternate movement was to be produced solely by the expansion and condensation of air, arising from the intermittent action of the rays of the sun.—M. Arago.

It is here to be observed, that Hero's apparatus spoken of by M. Arago in the above note, is not the æolipile mentioned at p. 23. *There*, steam is the power, and the motion is continuous.—Tr.

rapidity. Papin, whilst he says that the end may be attained " by various constructions, which may be easily imagined," points out none of those various constructions. He leaves to those who came after him, the merit both of the application of his fertile idea, and of the invention of those subordinate parts which alone can ensure the success of an engine.

In my earlier enquiries into the use of steam, I have had occasion to mention ancient philosophers of Greece and Rome; one of the most renowned mechanicians of the school of Alexandria; a Pope; a gentleman of the Court of Henry IV.; a hydraulist, a native of Normandy,—that province so fruitful in great men, and which has enriched the national Pleiades with a Malherbe, a Corneille, a Poussin, a Fontenelle, a Laplace, a Fresnel;—a member of the House of Lords; an English engineer; and finally, a French physician, member of the Royal Society of London. For the truth must out, that Papin, an exile for nearly the whole of his life, was only a correspondent of our Academy. But now, plain artisans, plain workmen, are about to enter the lists. Thus all ranks of society will be found to have united in creating an engine by which the whole world was to benefit.

In 1705, fifteen years after the publication of Papin's first memoir in the Leipzig Transactions, Newcomen and Cawley, the one an ironmonger, the other a glazier at Dartmouth in Devonshire, constructed,—(observe particularly that I do not say *devised*, for there is a wide difference,)—con-

structed a machine meant to serve as a pump, and in which there was a detached boiler wherein steam was generated. This engine, as well as Papin's little model, presents a vertical metal cylinder, closed below, open above, and a piston, fitting closely, intended to ascend and descend through the whole length of the cylinder. In the one apparatus, as well as in the other, as the steam gains a free admission into the lower part of the cylinder, it fills it, and thus counterbalances the pressure of the external air; the ascending movement of the piston is effected by means of a counterpoise. Finally, in the English engine, in imitation of Papin's, as soon as the piston has arrived at the limit of its ascent, the steam which had helped to elevate it, is cooled down; a vacuum is thus made throughout the whole space which the piston had just traversed, and the weight of the external atmosphere causes it forthwith to descend.*

* Switzer, in his system of Hydrostatics, already quoted, after giving a detailed account of Savery's Engine, says, p. 335,—"To finish this long account of the surprising Engine for the raising Water by Fire, I produce this last improvement of it by Mr. Thomas Newcomen, which makes it undoubtedly the beautifullest and most useful Engine that any age or country ever yet produced." Then after describing Newcomen's Engine, he says, p. 341,—"What I have to add in this place is, that as the best and most useful improvements which have been discovered either in Art or Nature, have, in process of time, been liable to improvement; so this of the Fire-Engine has been subject to the same. For this ingenious gentleman, to whom we owe this late invention, has, with a great deal of modesty, but as much judgment, given the finishing stroke to it. It is, indeed, generally said to be an improvement to Mr. Savery's Engine; but as I am well informed that Mr. Newcomen was as early in his invention as Mr. Savery was in his, only the

To effect the proper cooling, Papin, as you already know, was contented with removing the

latter, being nearer the Court, had obtained his Patent before the other knew it, on which account Mr. Newcomen was glad to come in as a partner to it."

Newcomen and Cawley became associated with Savery in the Patent obtained in 1705. The engine has, however, always borne the name of Newcomen.

The improvements introduced into it were very considerable, compared with the scheme of Papin, or the engine of Savery. In those first made, one cylinder was placed within another, and the interstice was filled with cold water, which effected the condensation with less trouble than the affusion of water. The piston was tightened by packing with leather or rope, and by a stratum of water upon it. A separate boiler was used, as had been done by Savery, for the generation of the steam, and the consumption of water in it was supplied by a pipe from the top of the piston. A snifting-valve was applied for blowing out the air, and an eduction-pipe for getting rid of the water arising from condensation, with improved mechanism of cocks and valves. But the great invention for rendering the power applicable to practical purposes, consisted in a working lever, or great beam moving on a centre, one end being connected with the piston-rod, by means of an arch and chains, and the other with the pump to be worked by it, having a counterpoise for the piston. The subsequent introduction of the cold water into the inside of the cylinder, and the working of the cocks or valves from the great beam, as stated in the text, were important points; and, by the last, the steam-engine was rendered a self-acting machine. The details underwent much improvement in the hands of Beighton, and finally of the great engineer Smeaton. See the particulars in Farey, Treatise on the Steam-Engine, pp. 138-204. The historical and mechanical information there given by this author, and indeed down to p. 308, will be found very deserving of an attentive perusal.

It results from the facts we have adduced in the notes pp. 41 and 50, that of the above machine, the first idea of the cylinder, packed piston and rod, and the use of the pressure of the atmosphere as a power, belong to Otto Guericke; the forming a vacuum by the condensation of steam in the cylinder to Papin; the separate boiler, and perhaps parts of the mechanism of the valves, &c. to Savery. But, whether the ironmonger and the glazier of Dartmouth were

fire which heated the base of his little metal cylinder. Newcomen and Cawley adopted a process in all respects greatly preferable; they caused an ample quantity of cold water to flow into the circular space contained between the outside of the cylinder of their engine, and a second cylinder, a little larger, which enclosed the first. The cold was gradually communicated to the whole thickness of the metal, and at last reached the steam itself.*

Papin's machine, thus improved in the mode of cooling or condensing the steam, engaged the attention of proprietors of mines to a very great degree. It spread rapidly through some of the counties of England, and was there of considerable

acquainted with what Otto and Papin had described in languages probably to them unknown, can only now be guessed at. That they knew something of what Savery had carried into practice six years before is likely, although Switzer appears to consider that they invented the whole. In the history of arts and sciences there have been many cases of apparent coincidence of inventions, of which, the theory of fluxions, bringing into opposition the great names of Newton and Leibnitz, forms the most illustrious instance.—Tr.

* Savery had already had recourse to a stream of cold water which he threw on the outer sides of a metallic vessel, to condense the steam which that vessel contained. Such was the origin of his partnership with Newcomen and Cawley: but it must not be forgotten that Savery's patent, his engines, and the work in which he describes them, are many years later in date than the papers written by Papin.—M. Arago.

But, as Papin's first process was conducted in a way which M. Arago admits was "scarcely tolerable even in an experiment intended to verify the accuracy of a principle," and at such an expense of fuel and labour, as to make it confessedly of no use in practice; and, as on the appearance of Savery's invention, Papin abandoned his own, and imitated the new one, but without success; we beg to refer, for a statement of the dates and circumstances of the respective inventions, to the notes given above at pp. 41 and 50.—Tr.

use. The slowness of its motions, unavoidably consequent on the length of time which the steam required to cool, and lose its elasticity, was however the subject of deep regret. Accident fortunately pointed out a way of remedying this inconvenience.

In the beginning of the eighteenth century, the art of boring large metal cylinders, and of closing them hermetically by means of moveable pistons, was yet in its infancy. Thus in Newcomen's first engines, the piston was covered over with a layer of water, intended to fill the interstice between the circumference of that moveable part and the internal surface of the cylinder. To the great amaze of the constructors, one of their engines began one day to move with much more than its ordinary rapidity. After repeated investigations, it was clearly proved, that on that day the piston had a hole in it; that cold water fell into the cylinder in very small drops, and that in passing through the steam, they caused it rapidly to disappear. From this accidental observation, is to be dated the complete abandonment of the application of cold from without, and the adoption of the rose-head * for the purpose of injecting a shower of cold water through the whole interior of the cylinder at the instant marked for the descent of

* In French, *pomme d' arrosoir*. The term *rose-head* seems to be derived from the French *arrosoir* or *rosée*, or perhaps from the Latin *ros*. In the first engines in which the injection was introduced into the cylinder, the water appears to have spurted straight up from the end of the injection pipe.—Tr.

the piston. The alternate motion thus acquires all the rapidity desirable.

Let us see whether accident has not also had some share in another equally important improvement.

Newcomen's first engine required the closest attention on the part of the person who had constantly to open or shut certain cocks, either to admit the steam into the cylinder, or to inject the cold shower which was to condense it. This person happened on one occasion to be a lad of the name of Henry Potter.* This boy, unhappy at hearing the joyous cries of his companions then at play, ardently longs to go and join them, but the work with which he had been entrusted would not admit of half a minute's absence. His brain becomes excited,—passion inspires him with genius,—he discovers relations of parts of which till then he had no suspicion. Of the two cocks, the one should be opened at the moment when the beam, which Newcomen first introduced with so much advantage into his engines, has completed its descending movement; and, similarly, it must be shut at the close of the contrary movement. Of the other cock, the management is directly the reverse. The positions of the beam and of the two cocks have a necessary dependence on each other. Potter seizes on this observation; he perceives that the beam may be used to communicate

* In Desaguliers, vol. II. p. 533, edit. 1744, quoted by Stuart, p. 66, by M. Arago in the Annuaire for 1830, p. 210, &c. &c., this idle but ingenious boy is called *Humphry* Potter.—Tr.

to the other parts all the motions which the play of the engine requires, and he forthwith realises his conception. The ends of some strings are without delay attached to the handles of the cocks; at their opposite extremities, Potter ties them to points, properly chosen on the beam; the pull which this causes upon some of the strings as it ascends, and upon the others as it descends, serves in place of the efforts of the hand; for the first time the steam-engine works by itself; for the first time no other workman is seen near it than the stoker, who from time to time goes to stir up and feed the fire under the boiler.

For the strings of young Potter, the manufacturers very soon substituted stiff vertical rods, fixed to the beam, and provided with several pegs, which could press upwards or downwards the handles of the various cocks or valves. The rods have, in their turn, been replaced by other combinations; but, however humiliating such a confession may be, all these inventions are merely modifications of the mechanical contrivance which was suggested to a boy by the desire of going to play with his young companions.

There are preserved in the cabinets of natural philosophy, a great number of machines, on which industry had founded high hopes, but which, from the expense of their working or maintenance, have come to be employed merely as instruments for demonstration. Such would also have been the final destination of Newcomen's engine, at least in those places where fuel is not plentiful, if the labours of

Watt, of which it remains for me to present you with an analysis, had not succeeded in giving it an unhoped for perfection. This perfection must not be viewed as the result of any casual observation, or of any single ingenious inspiration; its author arrived at it by indefatigable labour, by experiments of excessive nicety and delicacy. Watt would seem to have taken for his guide that famous maxim of Lord Bacon:—"To write, to speak, to meditate, to act, when one is not well provided with *facts* which serve as guide-posts to the mind, is to navigate, without a pilot, along a coast thick-set with dangers,—is to launch out into the boundless ocean without compass and without rudder." *

There was, in the collection belonging to the University of Glasgow, a small model of Newcomen's steam-engine, which could never be got to work well. Anderson, the Professor of Natural

* "Quemadmodum seculis prioribus, cum homines in navigando per stellarum tantum observationes cursum dirigebant, veteris sane continentis oras legere potuerunt, aut maria aliqua minora et Mediterranea trajicere; priusquam autem oceanus trajiceretur, et novi orbis regiones detegerentur, necesse fuit, usum acus nauticæ, ut ducem viæ magis fidum et certum, innotuisse: Simili prorsus ratione, quæ hucusque in artibus et scientiis inventa sunt, ea hujusmodi sunt, ut usu, meditatione, observando, argumentando, reperiri potuerint; ut pote quæ sensibus propiora sint, et communibus notionibus fere subjaceant: Antequam vero ad remotiora et occultiora naturæ liceat appellere, necessario requiritur, ut melior et perfectior mentis et intellectus humani usus et adoperatio introducatur." This passage is taken from the "Præfatio de statu Scientiarum," which accompanies the great treatise "de Augmentis Scientiarum," vol. VII. p. 25, ed. 1826. But the same metaphor is frequently repeated throughout Lord Bacon's works, and is usually expressed with great force and beauty.—TR.

Philosophy,* gave it to Watt to be repaired. Under the powerful hand of the artist, the faults of its construction disappeared; thenceforward, the apparatus annually went through its performance in the lecture-rooms, before the eyes of the wondering students. An ordinary man would have been satisfied with this success; Watt, on the other hand, beheld in it, according to his usual custom, occasion of still more serious study. His researches were made to bear successively on all the points which seemed capable of throwing light on the theory of the machine. He determined the increase, in volume, of water when it passes from the liquid state to that of vapour,—the quantity of water which a given weight of coal can convert into steam,—the quantity, in weight, of steam expended at each stroke by a Newcomen's engine of given dimensions,—the quantity of cold water which must be injected into the cylinder in order to give to the downward stroke of the piston a certain specified force,—and, lastly, the elasticity of steam at different temperatures.

There was here sufficient occupation for the whole life of a laborious natural philosopher, yet Watt found means of bringing to a happy conclusion enquiries thus numerous and difficult, without interfering with the labours of the work-shop. Dr. Cleland had lately the kindness to offer to conduct me to the house, near the harbour of

* Mr. James Anderson, the founder of the Andersonian Institution in Glasgow, succeeded Dr. Dick as Professor of Natural Philosophy in the University, in 1757.—Tr.

Glasgow, to which our fellow-member, on quitting his daily labours, was wont to retire and become an experimentalist. It was razed to the ground! Our vexation was extreme, but of short duration. Within the site, which could still be discerned by the traces of the foundations, ten or twelve able-bodied working men seemed busied in hallowing the nursery of modern steam-engines;—they were hammering, with repeated blows, various parts of boilers, the united dimensions of which at least equalled those of the humble habitation which had lately disappeared. On that site, and in like circumstances, the most elegant mansion, the most magnificent monument, the finest statue, could not have awakened so many thoughts as did those gigantic caldrons.

If the properties of steam are still present to your mind, you will at once perceive that the economical action of Newcomen's engine seems to require two incompatible conditions. When the piston descends, the cylinder must be cold, for, otherwise, it then meets with a vapour still strongly elastic, which greatly hinders its progress, and diminishes the effect of the pressure of the external atmosphere. When, again, steam at 100° [centigr.] passes into the same cylinder, if the sides are cold, that steam heats them by being itself partially liquefied, and, up to the very moment at which the temperature of the sides becomes also 100°, the elasticity of the steam is greatly diminished; hence a retardation of the movement, because the counterpoise does not raise the piston until there exists

in the cylinder an expansive power capable of counterbalancing the pressure of the atmosphere; hence, also, an increase of expense, because steam, as I have already explained, has a very high commercial value. All doubt as to the immense importance of this consideration of economy will be removed from your minds, when I state that the Glasgow model used, at each stroke, a volume of steam many times greater than the bulk of the cylinder. The expense of steam, or, what comes to the same thing, the expense of fuel, or, if you like it still better, the pecuniary expense, which is quite indispensable for keeping up the movement of the engine, would be many times less if a way could be found of getting rid of the successive heatings and coolings, the inconveniences of which I have just been pointing out.

This problem, to all appearance admitting of no solution, Watt has solved by the most simple contrivance.* All that he did was to add to the machine, as formerly constructed, a vessel quite separate from the cylinder, and communicating with it only by a narrow tube with a cock. This vessel, which is now known by the name of the *Condenser*, is the principal of Watt's inventions. Notwithstanding all my desire to be as brief as possible, I cannot pass on without explaining its mode of action.

If a free communication exist between a cylinder

* See Mr. Watt's own interesting account in Brewster's edition of Robison's Mechanical Tracts, vol. ii. STEAM-ENGINE, pp. 113 to 120.—TR.

full of steam, and a vessel void both of steam and air, a part of the steam from the cylinder will pass with great rapidity into the vessel, and will cease to flow in only when the elasticity is the same in all parts. Let us suppose that, by means of a copious and constant injection of water, the whole interior and sides of the vessel are kept always cold; the steam will then be condensed as soon as it enters, all the steam with which the cylinder was at first filled, will also, in its turn, come to be annihilated; the cylinder will thus be left unoccupied by steam, without its sides being in the least degree cooled, and the fresh steam with which it will be necessary again to fill it will lose nothing of its expansive energy.

The condenser draws into itself the whole steam from the cylinder, partly because it contains cold water, and also because the rest of its room is not filled with elastic fluids. But the moment that the first condensation of steam has taken place in it, these two conditions of success are removed; the condensing water becomes heated by absorbing the latent heat of the steam; a considerable quantity of steam is formed from this heated water; and besides, the cold water contained atmospheric air, which, during the process of heating, will have been disengaged. If the hot water, the steam, and the air which the condenser contains, were not got rid of after each operation, the result would be, that it would cease to work. Watt effects this triple evacuation by means of a

common pump, which is called the *air-pump*, of which the piston has a rod conveniently connected with the beam which is worked by the engine. The force required to keep the air-pump going, diminishes in so far the power of the engine ; this, however, bears but a small proportion to the waste which was formerly caused, on the old system, by the steam being condensed on the cold sides of the cylinder.

One word more, and the advantages of another of Watt's inventions will be made apparent to every one.

In Newcomen's engine, when the piston descends, it is because the atmosphere presses it down. This atmosphere is cold ; it must, therefore, cool the sides of the metal cylinder, open at the top, over the surface of which it successively spreads. This loss of heat cannot be recovered, during the upward movement of the piston, but at the expense of a certain quantity of steam. No such expenditure takes place in the *modified engines* of Watt. In these the atmospheric pressure is altogether done away with, in the following manner.

The cylinder is closed at the top by a metal lid, perforated only in its centre by an opening nicely fitted with greased tow, and well stopped,* through which the cylindrical rod of the piston moves freely, yet without allowing a passage to the air or steam. The piston thus separates the cylinder into two

* Called the *stuffing-box*.—Tr.

totally distinct and closed spaces. When it is to descend, the steam from the boiler is admitted freely into the upper space, by a pipe conveniently placed, and presses the piston downwards, as the atmosphere did in Newcomen's engine. This movement meets with no obstruction, as, while it is taking place, only the lower space of the cylinder is suffered to communicate with the condenser, in which all the steam of the lower space is turned into water. Whenever the piston has reached the bottom, the mere turning of a cock is sufficient to allow of a communication being made between the two spaces of the cylinder, situated, the one above, and the other below the piston ; of their being filled with steam of an equal degree of elasticity ; of the piston being pressed just as much downwards as upwards ; [*i. e.* being *in equilibrio*] ; of its re-ascending to the top of the cylinder, as in Newcomen's atmospheric engine, solely by the action of a light counterpoise.

By extending his researches as to the best means of economising the steam, Watt further reduced, almost to nothing, the loss which arose from the cooling of the cylinder from without. In order to this, he enclosed the metal cylinder in a wooden cylinder of a larger diameter, and filled the intervening circular space with steam.*

* Mr. Watt's words, in his specification of 1769, are, "first, by inclosing it (*i. e.* the cylinder) in a case of wood, or any other materials that transmit heat slowly ; secondly, by surrounding it with steam, or other heated bodies ; and, thirdly, by suffering neither

There we have the steam-engine completed. The great improvements which it has just been shewn to have received from the hand of Watt, are manifest; their immense utility cannot admit of a doubt. You will, then, expect to see it without loss of time replace, as an apparatus for pumping, the engines of Newcomen, comparatively ruinous in expense. But you are mistaken; the author of a discovery has always to contend against those whose interests he may injure,—against the obstinate champions of all that is old,—and, lastly, against the envious. These three classes it must, alas! be owned, together make up the great majority of the public. And in my estimate I do not take into account those who come under more than one of these classes, in order that I may not arrive at a paradoxical conclusion. This united phalanx of opponents time alone can scatter, and put to flight; but time is not all that is necessary; they must be vigorously and incessantly assailed; different modes of attack must be tried; following therein the example of the chemist, who is taught by experience that certain compounds require, for their complete solution, the use of several acids in succession. That strength of mind, that stedfastness of purpose, which in the end triumph over the best concerted intrigues, may not be found united with

water, or any other substance colder than the steam, to enter or touch it during that time." In point of practice, he surrounded the cylinder with a metallic case containing steam, which he again protected by a covering of wood, or other materials which conduct heat slowly.—Tr.

inventive genius. Of this, if other instances were wanting, Watt would be a convincing proof. His grand invention, his felicitous idea as to the possibility of condensing the steam in a vessel quite detached from the cylinder where the mechanical action is carried on, is of the date of 1765. Two years pass away, and he hardly makes any progress in attempting the trial of it on a great scale. His friends at last put him in communication with Dr. Roebuck, the original founder of the vast iron-work at Carron, which is still so famous. The engineer and the projector go into partnership; Watt gives up to his partner a two-thirds share of his patent; an engine is constructed on the new principles; it fulfils all the expectations which the theory led them to entertain; its success is complete. But while this was going on, Dr. Roebuck met with some reverses of fortune; Watt's invention would most undoubtedly have repaired them; all that was required was to go and borrow some money; but our fellow-member found it easier to give up his invention, and change his course. In 1767, while Smeaton* was carrying on trigonometrical

* John Smeaton, the father of civil engineering in Great Britain, was a most able and highly gifted man. His "Narrative of the building, and description of the construction of the Eddystone Light-house," fol., of which the first edition appeared in 1791, and the second in 1793, is one of the most instructive and interesting books ever published. The Collection of his Reports, published in 1812, in three volumes quarto, with a volume of Miscellaneous Papers in 1814, under the auspices of Sir Joseph Banks, and of the leading members of the Society of Civil Engineers, of which he was the founder, (and which Society still continues, although a later one,

and levelling operations between the two rivers Forth and Clyde, as a prelude to the gigantic operations of which that part of Scotland was afterwards to become the theatre, we find Watt carrying on similar operations along a rival line, which was called the Lomond passage. At a later period we find him drawing the plan, and superintending the execution of a canal intended to convey the produce of the Monkland collieries to Glasgow. Several projects of the same kind,—among others, that of the navigable canal through the isthmus of Crinan, which Mr. Rennie has since completed; recondite and laborious investigations in regard to certain improvements in the harbours of Ayr, Glasgow, and Greenock; [the deepening of the river Clyde; the rendering navigable the rivers Forth and Devon, and the water of Leven; the planning of a canal from Macrihanish Bay to Campbeltown, and of another between the Grand canal and the harbour of Borrowstoness];* the building of Hamilton and Rutherglen bridges; surveys and plans of the land through which the celebrated Caledonian Canal was to pass, engaged the attention of our fellow-member till the close of 1773. With-

differently constituted, has usurped the name), are an imperishable record of his talents and labours. He formed a just estimate of the rising talents of Mr. Watt in his own profession, and gave them his commendation; and when, at a later period, the steam-engines of Boulton and Watt were introduced, he was among the first to bear testimony to their advantages, after having carefully ascertained them by experiment. It need scarcely be added, that two such men continued their esteem and friendship through life.—Tr.

* We have here supplied some works omitted by M. Arago.—Tr.

out in any way wishing to detract from the merit of these labours, I may be permitted not to extend their importance beyond their mere local interest, and to affirm, that in order to their conception, direction, and execution, there was no need whatever for calling in the assistance of James Watt.*

If, forgetting my duty as the organ of the Academy, I were to try to supply you with matter for amusement, rather than with profitable truths, I should here find materials for a striking contrast. I could instance such and such an author, outrageously clamouring at our weekly meetings for permission to communicate the small remark, the trivial reflection, the little note, thought of and written down but the evening before. I might exhibit him cursing his destiny, when the established regulations, and the order of enrolment of some earlier applicant, make his reading be postponed for eight days; but during that agonising week leave him, as a hostage, his sealed packet deposited in our archives. On the other hand, we should see the creator of an engine, destined to be the beginning of a new era in the annals of the world, bearing, without a murmur, the ignorant neglect of capitalists, and for eight years bending his

* We cannot think that these were such trivial matters as they may appear to one conversant with the present state of civil engineering; for be it remembered that they were the performance of a young and self-taught engineer, at a period when such operations were only beginning to be carried on by a Brindley and a Smeaton. —Tr.

lofty genius to a succession of plans and minute levellings, and the most wearisome estimates of excavations, and embankments, and courses of masonry. But let us be satisfied with remarking all that serenity of disposition, that moderation of desire, that true modesty, which Watt's philosophy displayed. So great an indifference, however noble the causes from which it proceeded, had its faults. It is not without reason that society pursues with strong reprobation those of its members who withdraw from circulation the gold amassed in their coffers; and are they less blame-worthy, who deprive their country, their fellow-citizens, and their age, of those treasures, a thousand-fold more precious, which are the offspring of thought; who keep to themselves immortal creations, the source of the noblest and purest intellectual enjoyments; who do not enrich the working classes with mechanical combinations which would multiply to an unlimited extent the products of industry; which would, to the great advantage of civilisation and humanity, gradually diminish the effects of the inequality of ranks, and one day enable us to go all over the most common workshops without ever finding there the heart-rending spectacle of fathers of families, and unfortunate children of both sexes, reduced to a state little better than that of brutes, and hastening to the grave?

In the early months of the year 1774, after having overcome the indifference of Watt, his friends brought him into connection with Mr. Boulton of

Soho, near Birmingham,* a gentleman equally distinguished by his knowledge of the arts, and his

* This was chiefly brought about by Dr. William Small, a Scotch physician, who, after having practised some time in America, settled in Birmingham. He was brother to Dr. Robert Small, the author of "An Account of the Astronomical Discoveries of Kepler," &c., and is described by Mr. Keir in his life of Day, as joining "to the most extensive, various, and accurate knowledge in the sciences, in literature, and in life, engaging manners, a most exact conduct, liberality of sentiment, and an enlightened humanity." Mr. Watt had become acquainted with him upon a journey to England, about the year 1768; and from that time an interesting correspondence was kept up between these two friends, both respecting Mr. Watt's invention, of which he wished Dr. Small to take a share with Mr. Boulton, and also as to improvements in various arts, which suggested themselves to their inquisitive minds. Dr. Small's health induced him to decline entering into any other business, and he died in 1775, about the time that the partnership of his two friends was brought to bear. Epitaphs were written upon him by Mr. Day, and by Dr. Darwin, the latter of which was inscribed on a tablet, surmounted by an urn, in Mr. Boulton's grounds. We give it here, that the memory of a man who was venerated by both Mr. Watt and Mr. Boulton, may be preserved along with that of his attached friends;—

Ye gay and young, who, thoughtless of your doom,
Shun the disgustful mansions of the dead,
Where melancholy broods o'er many a tomb
Mould'ring beneath the yew's unwholesome shade;

If chance ye enter these sequester'd groves,
And day's bright sunshine for a while forego,
O leave to Folly's cheek the laughs and loves,
And give one hour to philosophic woe!

Here, while no titl'd dust, no sainted bone,
No lover bending over beauty's bier,
No warrior frowning in historic stone,
Extorts your praises, or requests your tear;

Cold Contemplation leans her aching head,
On human woe her steady eye she turns,
Waves her meek hand, and sighs for Science dead,
For Science, Virtue, and for SMALL she mourns.

See Keir's Life of Day, 1791, pp. 29, 93, and 111; and Miss Seward's Memoirs of Darwin, 1804, p. 24.—Tr.

enterprising spirit.* The two friends petitioned Parliament for an extension of the patent; for

* In the notes which he added to the last edition of Professor Robison's Essay on the steam-engine, Watt, speaking of Mr. Boulton, expressed himself in these terms; "In 1774-5, I commenced a partnership with Mr. Boulton, which terminated with the exclusive privilege in the year 1800, when I retired from business; but our friendship continued undiminished to the close of his life. As a memorial due to that friendship, I avail myself of this, probably a last public opportunity, of stating, that to his friendly encouragement, to his partiality for scientific improvements, and his ready application of them to the processes of art; to his intimate knowledge of business and manufactures, and to his extended views and liberal spirit of enterprise, must in a great measure be ascribed whatever success may have attended my exertions."

When the connection spoken of in the text was formed, Mr. Boulton's manufactory had already been for some years established at Soho. It was the first which had been formed on such a large scale in England, and is still remarked for the elegance of its architecture. There, Boulton manufactured all sorts of admirable works in steel, plated goods, silver, and or-moulu; nay, even astronomical clocks, and paintings on glass. During the last twenty years of his life, Boulton devoted his attention to improvements in the coining of money. By uniting some processes, originating in France, with new kinds of presses and an ingenious application of the steam-engine, he was enabled to attain at once an excessive rapidity of execution, and great perfection in the articles produced. It was Boulton who re-coined, for the English government, the whole copper specie of the United Kingdom. The economy and excellence with which this great work was accomplished, rendered counterfeits nearly impossible. The executions which in London and Birmingham were every year till then unhappily of frequent occurrence, altogether ceased. It was on occasion of this that Dr. Darwin exclaimed, in the notes to his "Botanic Garden," "If a civic crown was given in Rome for preserving the life of one citizen, Mr. Boulton should be covered with garlands of oak!" Mr. Boulton died in 1809, aged 81.—M. Arago.

To the above notice of Mr. Boulton, we may add, that he planned and directed the arrangement of the machinery for the British mint on Tower-hill, and executed that for the coining department. He did the same for the great national mints of Petersburg and Copen-

Watt's grant was dated 1769, and had only a few years to run. The bill gave rise to the most animated discussion. "After a series of various and violent opposition," writes the celebrated mechanician to his aged father, "I have at last got an Act of Par-

hagen; as his son has since done for the still more extensive and splendid establishments of the East India Company, the Calcutta and Bombay mints. Mr. Boulton struck several fine medals at his mint at Soho, commemorative of persons and events in the late war; and, in particular, a beautiful one of Lord Nelson, on the occasion of the victory of Trafalgar, 21st October, 1805; the reverse representing the British fleet bearing down into action in two lines, with the motto, "ENGLAND EXPECTS EVERY MAN WILL DO HIS DUTY." In a truly patriotic spirit, and with the consent and approbation of Government, he presented one to each officer, sailor, and private engaged in that memorable action.

For a graphic and poetical account of the coining apparatus at Soho, as well as of the wonders of steam generally, see Canto First of "The Botanic Garden," in which the poet, among some predictions not yet verified, has this remarkable one:—

"Soon shall thy arm, unconquer'd Steam! afar
Drag the slow barge, or drive the rapid car!"

It is interesting to compare this with Mr. Watt's words in the narrative of his invention in Robison's Mech. Phil. vol. ii., article STEAM-ENGINE. "My attention was first directed, in the year 1759, to the subject of steam-engines by the late Dr. Robison, then a student in the University of Glasgow, and nearly of my own age. He at that time threw out an idea of applying the power of the steam-engine *to the moving of wheel-carriages*, and to other purposes; but the scheme was not matured, and was soon abandoned on his going abroad." In the specification of his patent of 1784, however, Mr. Watt described a portable steam-engine and machinery for moving wheel-carriages. See the seventh article of the specification. And we find the following passage in a letter from Dr. W. Small to Mr. Watt, dated September, 1768;—"Your very clever friend Mr. Robison and his pupil passed Friday evening with me, to my great satisfaction. I told them I hoped soon to travel in a Fiery Chariot of your invention." "The Botanic Garden" was printed in 1791. A short and popular, but instructive sketch of the history of the steam-engine is likewise given in No. XI. of the "Additional Notes" appended to the same poem.—TR.

liament vesting the property of my new Fire Engines in me and my assigns, throughout Great Britain and the plantations, for twenty-five years.* * This affair has been attended with great expense and anxiety, and without many friends of great interest I should never have been able to have carried it through, as many of the most powerful people in the House of Commons opposed it." It seemed to me matter of curious enquiry to discover to what class in society belonged those parliamentary personages of whom Watt here speaks, and who refused to the man of genius a small portion of the riches which he was about to create. Judge of my astonishment when I found at their head the celebrated Burke! Was it, then, possible, that a man might be devoted to deep study, might be learned and upright, might, in an eminent degree, possess those oratorical powers which move and carry away political assemblies, and yet might at times be destitute of the most ordinary good sense?* As for the rest, since the wise and important changes which Lord Brougham has introduced into the law relating to patents,† inventors will not now have to undergo the long series of vexatious difficulties of which Watt was made to drink so deeply.

As soon as Parliament had granted a fresh term of twenty-five years to Watt's patent, that engineer, in partnership with Boulton, set a-going at

* Mr. Burke's opposition is believed to have arisen, not from any hostility to Mr. Watt or his patent; but simply from a sense of duty in defending what he conceived, or what were represented to him to be the claims of a constituent.—Tr.

† See 5 & 6 Will. IV. c. 83, amended by 2 & 3 Vict. c. 67.—Tr.

Soho those establishments, which have been to the whole of England the most useful school of practical mechanics. There, the partners very soon were superintending the construction of steam-engines of very large dimensions; and repeated trials showed that, with equal power, they consumed three-fourths less fuel than Newcomen's had done. The moment this was known, the new engines came rapidly into use in all the mining districts, and especially in Cornwall. Boulton and Watt received,* as their remuneration, the third part of the value of the whole fuel which was saved by each of their engines. You may judge of the commercial importance of the invention by the following well-attested fact:—In Chace-water mine alone, where three pumps were at work, the proprietors found their account in purchasing up the rights of the inventors for an annual sum of 60,000 francs. Thus, in one concern alone, the use of the condenser in lieu of injecting water into the cylinder, had effected a saving in fuel of more than 180,000 francs per annum.†

* *Stipulated* to receive, but in fact did not receive nearly that proportion. Where the agreement was not for a fixed sum, the savings were computed from the number of strokes made by the engine; to ascertain which, a small instrument, or piece of clockwork, called a *counter*, was invented by Mr. Watt, which, being locked up in a box, and fixed upon the working beam, told, when opened, the number of strokes the engine had made since the last inspection.—Tr.

† About the same time, 1776-79, several engines were made for the water-works in London; and their fame had extended to France, where one was erected for Mr. Jary upon the Mines de Niort in Brittany in 1779; and, immediately afterwards, one for the Messrs. Perrier, for supplying Paris with water from the Seine. They also soon came into demand for canals, iron works, &c.—Tr.

Men readily make up their minds to pay the rent of a house or farm; this good-will deserts them when there is question of an idea, whatever advantage, whatever profit it may have been the means of procuring. Ideas! but are they not conceived without fatigue and without trouble? And who can show that, in process of time, they would not have occurred to any one? In such matters, a few days, or months, or years of priority, should give no claim to any exclusive privilege.

To these opinions, which surely in this place I am not called upon to characterise as they deserve, custom had all but given the force of settled law. It seemed as if men of genius, *inventors of ideas*, were to be for ever debarred from material enjoyments; it was natural that their history should continue to resemble a legend of martyrs!

Whatever may be thought of these reflections, it is certain that the Cornwall miners paid every year with greater reluctance, the rent which was due to the Soho engineers. They took advantage of the first difficulties thrown in the way, by pirates of the invention, to pretend that they were freed from all their obligations.* The question was an

* Long afterwards, when Mr. Watt ceased to superintend their engines, the miners were taught, by experience, that a selfish or short-sighted economy seldom fails to defeat its own petty ends. This is well illustrated in the following passage, taken from an "Account of the Steam-Engines in Cornwall," by Mr. W. J. Henwood. "Shortly after the expiration," says Mr. Henwood, "of Messrs. Boulton and Watt's patent right, they relinquished the superintendence of the steam-engines which they had erected on the Cornish mines; and they were, consequently, committed to the care of those who had been convicted of infringements on the patent, or to that of the

important one, and might have seriously affected our fellow-member's position in society; so he gave it his whole attention, and became a lawyer. It is hardly worth while, at the present day, to detail all the particulars of the long and expensive litigation which Boulton and Watt had to carry on, and in which they were finally successful; but since I have so lately mentioned Burke among the adversaries of the great mechanician, it seems but right to record that, to compensate for this, a Roy,*

mine-agents. None of those persons having been acquainted with the reasons which had influenced Mr. Watt's operations, in a very short time the duty, which had been advanced to an average of above *twenty millions* of pounds weight, lifted one foot high by the consumption of a bushel of coal, subsided to an average not exceeding fourteen millions; and the performance of many engines was not more than *six millions*.

"Some of the pirators who were intrusted with the erection of new engines, having, during the continuance of the patent, found it of importance to get their engines into operation as speedily as possible, without regard to accuracy or proportion, with the sanction of the miners, still continued to pursue the same practice; the consequence of which was, that the scientific precision which had been introduced by Mr. Watt, was regarded as an object of secondary consideration. Some of those erections (for they were scarcely worthy of being termed machines) could only have been viewed as caricatures of the original. Others followed Mr. Watt's steps as closely as, without the assistance of science, they were enabled to do, and produced some tolerable imitations. But all fell more or less short of what had been obtained whilst his superintendence continued."—Brewster's Edinburgh Journal of Science, vol. x. 1829, p. 34. Mr. Henwood has various papers in the Journal from which the above is taken, containing many important facts as to the performances of the engines in Cornwall.—Tr.

* Colonel, afterwards General Roy, author of "The Military Antiquities of the Romans in Britain," fol. 1793; of a Survey and Map of Scotland; of "Experiments and Observations made in Britain, in order to obtain a rule for Measuring Heights with the Barometer;" of the "Measurement of a Base on Hounslow-Heath,"

a Mylne,* a Herschell,† a Deluc,‡ a Ramsden,§ a Robison,‖ a Murdock, a Rennie, a Cum-

preparatory to the Trigonometrical Survey, and of other papers connected therewith, in the Transactions of the Royal Society, from 1777 to 1790. He bore testimony to the advantages and originality of Mr. Watt's inventions, before the Committee of the House of Commons, in 1775.—Tr.

* Mr. Robert Mylne, the architect of Blackfriars Bridge, a structure of deserved celebrity, both for its elegance and the art employed in its construction, also gave evidence on the same occasion, as he did afterwards in the trials in the Court of Common Pleas in 1792 and 1796. He was one of the original Members of the Society of Civil Engineers, was extensively employed in that profession, and directed the Water-works of the New River Company. At his hospitable board at New River Head, Mr. Boulton and Mr. Watt were welcome guests, and the cares of law and business were forgotten in his cheerful society and that of his delightful family. See an excellent life of him in Chalmers' Biographical Dictionary, vol. xxii. ed. 1815.—Tr.

† Of the great astronomer, Dr., afterwards Sir William Herschell, it would be superfluous for us to speak. The voice of posterity has confirmed the admiration and fame awarded him by his contemporaries.—Tr.

‡ J. A. de Luc, Reader to Queen Charlotte, a distinguished Genevese philosopher, and author of several works on geology and meteorology. Mr. Watt, on his visits to the metropolis, was in the habit of passing some days at Windsor with these two celebrated men, with whom he lived on terms of the greatest intimacy.—Tr.

§ Jesse Ramsden, the well-known optician and mathematical instrument maker. A man of strong and original genius, with whom Mr. Watt often discoursed on the subjects of his first pursuits.—Tr.

‖ Dr. John Robison, Professor of Natural Philosophy in the University of Edinburgh, an eminent mathematician, and one of the most scientific mechanical philosophers of the last or any other age. We have already given an early instance of his regard for and attachment to Mr. Watt. It continued through life, and was warmly felt and reciprocated. Upon the occasion of the last trial in the Common Pleas, although suffering under an acute disorder, he hastened to town to give his evidence upon the invention of the separate condenser, which had been confided to him at the time it was made. To show that we have not exaggerated Dr. Robison's merits as a

ming,* a More,† a Southern, eagerly hastened to sustain, before the Judges, the rights of persecuted genius. Perhaps, also, it were proper to add, as a singular feature in the history of the human mind, that some of the barristers,—(I would here have the prudence to beg it to be observed, that I am speaking only of the barristers of a neighbouring country,)—that barristers, to whom malice is wont to ascribe a luxuriant superfluity of words, reproached Watt, against whom a formidable array of them had been retained, with having invented nothing but ideas. This, I may just mention, brought upon them, in presence of the Bench, this apostrophe of Mr. Rous:—"Go, gentlemen, and

philosopher, we subjoin the following testimony of the most competent witness. Mr. Watt, in one of his private letters in our possession, dated 7th February 1805, thus writes—"It was with great concern that I learnt, the other day, the death of my worthy friend Professor Robison. *He was a man of the clearest head and the most science of anybody I have known*, and his friendship to me ended only with his life, after having continued nearly half a century."—Tr.

* Mr. Alexander Cumming, F.R.S., an ingenious mathematician and mechanician, the author of "Elements of Clock and Watch-work adapted to Practice," a "Dissertation on the Influence of Gravitation, considered as a Mechanic Power," and a treatise on "The Destructive Effects of the Conical Broad Wheels of Carriages, with the Improving Effects of Cylindrical Wheels of the same breadth, as they regard the Roads, the labour of Cattle, &c." This was a subject on which he bestowed much ingenuity, and which made a great sensation at the time. He also constructed a magnificent organ for the Earl of Bute.—Tr.

† Mr. Samuel More, many years Secretary to the Society of Arts in the Adelphi, a good mechanician, and a gentleman well skilled in the history of all inventions relative to the arts. Of the other gentlemen named in the text, we shall have occasion to speak hereafter. They formed but a portion of the men of science and engineers who came forward to give their evidence on the occasion in question.—Tr.

approach this intangible substance, as you are pleased to call it,—this pretended abstract idea; —you will be crushed like flies, and leave no trace of your existence!"*

* In the Proceedings in Error in the cause Boulton and Watt *v.* Hornblower and Maberly, Mr. Gaselee argued the writ for the plaintiffs in error, and Mr. Holroyd for the defendants. This was in Michaelmas term 1798; and in Hilary term 1799, it was directed by the Court to be again argued, "not," as Lord Kenyon observed, "because it was not extremely well argued the last term," but because it involved some points of great novelty, nicety, and importance to the law. This was accordingly done by Mr. Serjeant Le Blanc for the plaintiffs in error, and by Mr. Rous for the defendants, when the Court expressed a unanimous and clear opinion, vindicating and establishing the rights of the patentees. Lord Kenyon was Chief Justice; the other Judges were Ashurst, Grose, and Lawrence.

The arguments of the Judges were printed at great length, along with those in the cause Boulton and Watt *v.* Bull; Mr. Rous' speech appeared in a separate pamphlet, and, as the opening of it indicates and overthrows the principal argument insisted on by the counsel for the opposite parties, and is, besides, most forcibly and justly expressed, we make no apology for citing it here.

"When I state to the Court, that a very large sum to the individual will depend on the issue of this cause; when I suggest that, in my humble opinion, no patent can stand, if the reasoning on which this is impeached shall be adopted by the Court; I only mean to claim the patient attention of your Lordships, and to offer an apology for myself, if I should deviate, in a case of much novelty, from the ordinary course of legal argument. Can it be seriously contended that the invention of Mr. Watt, which, during the space of nearly thirty years, has been admired by all Europe as the greatest *practical* advance ever made in the *arts*, is a mere *abstract* discovery in *science*? Can that which, with a single bushel of coals, will raise a foot high thirty millions of pounds weight, or six thousand hogsheads of water; which has brought into subjection to man, and submitted to his use, a power more than double the force of gunpowder; which has taught a beam, moving with this mighty force, to act as the pendulum of a clock, and keep pace with other clocks through the day; can these operations be performed by a mere abstract idea, neither tangible nor vendible? *If these gentlemen were to approach this intangible substance, as they are pleased to call*

The persecutions which a man of feeling encounters, where the strictest justice entitled him to expect unanimous testimonies of gratitude, seldom fail to dishearten him, and to sour his temper. Watt's naturally happy disposition was not proof against such severe trials. Seven long years of litigation had excited in him a feeling of indignation, which occasionally vented itself in strong expressions;—"We have been so beset by plagiaries," writes he to his friend Dr. Black, "that if I had not a very good memory of my doing it, their impudent assertions would lead me to doubt whether I was the author of any improvements on the steam-engine; and the ill-will of those we have most essentially served, whether such improvements have not been highly prejudicial to the commonwealth."

Watt, though keenly irritated, was not discouraged. His engines were at first, like Newcomen's, only simple pumps, mere instruments of exhaustion. In a few years, he converted them into agents applicable to all purposes, and of an unlimited power. His first approximation to this end, was the formation of *the double engine.*

To understand the principle on which it acts, let me refer to the modified engine,* of which I have already spoken. (See p. 66.) The cylinder is closed; the external air gains no admission into

it, with the same ignorance of what it is, with which they discourse upon it, they would probably be crushed like flies, and leave no trace of their existence!"—Tr.

* Mr. Watt's *Single Engine.*—Tr.

it; it is the pressure of the steam, and not that of the atmosphere, which makes the piston descend; it is simply by a counterpoise that the ascending movement is brought about; for, at the time when this movement takes place, the steam being allowed to circulate freely between the top and the bottom of the cylinder, presses upon the piston equally in both opposite directions. It is thus evident to all, that the *modified engine*, like Newcomen's, has no real power but during the downward stroke of the piston.

A very slight change will alter this, and furnish us with *the double engine*. In the engine known by this appellation, as in that which I have called the modified engine, the steam of the boiler, at the will of the engineer, is readily admitted above the piston, and impels it without any obstruction, since, at the same moment, the lower chamber of the cylinder is in communication with the condenser. This movement once completed, and a particular cock being opened, the steam issuing from the boiler can only enter the cylinder below the piston, which it raises up; the upper steam which had produced the descending movement, then finds its way into the condenser, where it is liquefied, and with which it has, in its turn, an uninterrupted communication. Turning the cock in the contrary direction, restores all the parts to their original position, as soon as the piston is at the top of its ascent. In this way, the same effects may be repeated any number of times.

The moving-power, as you see, is here exclu-

sively steam, and the engine, excepting the difference which depends on the weight of the piston, has the same power when the piston ascends as when it descends. For this reason, when it first appeared, it was appropriately termed the *double-acting engine.*

To render the application of his new moving-power easy and convenient, Watt had other difficulties to overcome. He had first to seek for a method of establishing an unyielding communication between the inflexible rod of the piston moving in a right line, and a beam working in a curve.* The solution which he gave of this important problem is perhaps his most ingenious invention.

Among the constituent parts of the steam-engine, you have doubtless remarked a certain jointed parallelogram. At each reciprocation of the stroke, it opens and closes, with the smoothness,—I had almost said with the grace,—which charms us in the gestures of an accomplished actor. Follow attentively with your eye the progress of its various changes, you will find that they are regulated by the most curious geometrical laws; and you will observe that three of the angles of the parallelogram describe arcs of a circle, whilst the fourth, the angle which elevates and depresses the rod of the piston, moves nearly in a right line. The immense utility of the result is still less striking to

* Mr. Watt's own words are—"It occurred to him, that if some mechanism could be devised moving upon centres, which would keep the piston-rods perpendicular, both in pushing and pulling, a smoother motion would be attained, and, in all probability, the parts would be less subject to wear."—Tr.

mechanical men, than the simplicity of the means by the aid of which Watt attained it.*

Power is not the only element requisite for succeeding in works of industry. Regularity of action is of no less importance; but what regularity can be expected of a moving-power which is generated by fire, fed by shovel-fulls of coal, and even that coal of different qualities, under the superintendence of a workman, sometimes of slender intellect, and almost always inattentive? The steam, which is the moving-power, will be so much the more abundant, —it will rush into the cylinder with so much the greater velocity,—it will make the piston move so much the faster,—as the heat of the fire is the more intense. Great inequalities in the motion would seem, then, to be unavoidable. The genius of Watt was called upon to obviate this great defect. The valves by which the steam passes out of the boiler

* These are the words in which Watt gave an account of the trial of this articulated parallelogram—"I was myself surprised at the perfection of its action; and in looking at it for the first time, I had all the pleasure of novelty which could have arisen had it been invented by another person."

Smeaton, who greatly admired the invention of Watt, thought, nevertheless, that in practice it never could become a usual and economical means of communicating a directly rotatory motion to the axes. He maintained that steam-engines would always be used to more advantage by being made to pump water directly. This liquid, when raised to a proper height, was then to be thrown into the buckets or upon the float-boards of ordinary hydraulic wheels. In this particular, the predictions of Smeaton have not been realised. Yet I saw, when I visited Mr. Boulton's establishment in 1834, an old steam-engine which is still employed to raise water from a great pool, and to throw it into the buckets of a large hydraulic wheel, when in dry seasons the water commonly used to turn the wheel is not sufficient for that purpose.—M. Arago.

to enter the cylinder, are not at all times equally open. When the rate of working of the engine is increased, these valves are partly shut; a given volume of steam must then take longer time to pass through them, and the acceleration is stopped. The opening, on the other hand, is enlarged as the motion becomes slower. The parts required for effecting these various changes connect the valves with the axes which the engine sets in motion, by the intervention of an apparatus, of which Watt found the principle in the regulator of the sails of wind-mills, which he called the *governor*, and which is also termed *the regulator by centrifugal force*. Such is its efficacy, that there was to be seen at Manchester a few years ago, in the cotton-mill of Mr. Lee, a man of great mechanical talents, a clock which was set in motion by the steam-engine used in the work, and which marked time very well, even beside a common pendulum clock.

Watt's *governor*, and a judicious use of the fly-wheel, are the secret, the true secret, of the wonderful perfection to which the manufactures of our day are brought. This it is, which now enables the steam-engine to work with a perfect freedom from all *jolting;* to this it is owing, that it can, with equal success, embroider muslins, or forge anchors; that it can weave the most delicate fabrics, or put in rapid motion the ponderous stones of a flour-mill. This may also explain how Watt could say, without fear of being reproached with exaggeration, that, to escape from the constant attendance of servants,

he would make himself be waited on, and, in case of sickness, have his food and medicines brought to him, by machines set in motion by his steam-engine. I am quite aware that people generally imagine that this smoothness of motion is gained at the expense of power; but they are mistaken, —utterly mistaken! The proverb, "much cry and little wool," *(faire beaucoup de bruit et peu de besogne)*, is true not only in the moral world; it is also an axiom in mechanics.

A few words more, and I have done with these technical details.

For some years past, it has been found very advantageous not to leave the communication between the cylinder and the boiler free during the whole time of each stroke of the engine. This communication is interrupted when the piston has performed, for instance, a third part of its course; the remaining two-thirds of the length of the cylinder are then traversed in virtue of the momentum acquired, and, above all, by the effect of the *expansion* of the steam. Watt had early pointed out this method.* Very competent judges have

* The principle of the expansion of steam, already clearly indicated in a letter from Watt to Dr. Small, dated in 1769, was put in practice at Soho in 1776, and at the Shadwell water-works in 1778, from considerations of economy. The invention and the advantages which were expected from it are described at length in the patent of 1782.—M. Arago.

The following is the passage in the letter to Dr. Small, above referred to. The letter is dated the 28th of May, 1769:—

"I mentioned to you a method of still doubling the effect of the steam, and that tolerably easy, by using the power of steam rushing into a vacuum, at present lost. This would do little more than

considered the discovery of expansion not less important, in an economical point of view, than that of the condenser. It is certain, that, since its adoption, the steam-engines in Cornwall are achieving unhoped-for results; that, with one bushel of coal, they do the work of twenty men, working for ten hours. Let us recollect, that, in the coal districts, a bushel of coal costs only ninepence, (about eighteen French sous,) and it will be demonstrated that Watt has reduced, over the greater part of England, the wages of a working man's average day's labour, of ten hours, to less than a sous of our money.*

double the effect, but it would too much enlarge the vessels to use it all. It is peculiarly applicable to wheel engines, and may supply the want of a condenser where force of steam only is used; for, open one of the steam valves, and admit steam until one-fourth of the distance between it and the next valve is filled with steam, shut the valve, and the steam will continue to expand and to press round the wheel with a diminishing power, ending in one-fourth of its first exertion. The sum of the series you will find greater than one-half, though only one-fourth steam was used. The power will, indeed, be unequal, but this can be remedied *by a fly*, or several other ways."—See Edinburgh Review for January 1809, p. 320.

For a full account of Mr. Watt's Expansion Engine, and of his patent of 1782, See Robison, STEAM-ENGINE, pp. 126–131, and, still more particularly, Farey, "Treatise on the Steam-Engine," pp. 339–352, where extracts from the specification are given.—TR.

* At a time when so many persons are interested about steam-engines with a directly rotatory motion, [steam-wheels,] I should be guilty of an unpardonable omission were I not to say, that Watt had not only conceived the idea, as is proved by his letters patent, but even made some of them. These engines were abandoned by him, not because they would not work, but because they appeared to him, in an economical point of view, notably inferior to the double engine with rectilineal strokes.

There are few inventions, great or small, of all those which are found so admirably united in the steam-engine, which are not the

Numerical calculations give so good an idea of the utility of the inventions of our fellow-member,

developement of some of the first ideas of Watt. Trace his labours, and, besides the points of principal importance particularly enumerated above, you will find him proposing engines to act without condensation; engines where, after having performed its office, the steam is dissipated in the atmosphere, intended for localities where there is a difficulty of obtaining cold water in abundance. The expansive principle, to operate in engines with several cylinders, will also figure among the projects of the Soho engineer. He it is who will be found to have suggested the notion of pistons perfectly tight, though composed exclusively of metallic parts;—it is again Watt who will be seen first to have had recourse to mercurial barometers in order to ascertain the elasticity of the steam in the boiler and in the condenser;—who devised a simple and permanent gauge by means of which the depth of water in the boiler may at any time be seen at a glance;—who, to prevent troublesome variations of the level, connected the motions of the feed-pump with those of a float;—who, when it was much wanted, applied to a hole in the lid of the principal cylinder of the engine a little apparatus, *the indicator*, so contrived as to make the law of the evacuation of the steam be exactly known in its relations with the piston, [and to be a measure of the power,] &c. &c. Had time permitted me, I should have shown that Watt was no less skilful and successful in his attempts to improve boilers, to diminish the loss of heat, and to consume completely the clouds of black smoke which escape from ordinary chimneys, to whatever height they may be raised.—M. Arago.

Mr. Watt, in his notes on Professor Robison, has stated his claim to the application of the crank, upon which he laid little stress, as he conceived it obvious to any one who considered the common foot lathe; and, in fact, it appears to have occurred to others, though probably unknown to him. To him we are unquestionably indebted for the beautiful contrivance of the sun and planet wheels, now little used, but of which we refer our readers to an excellent instance in the steam-engine of the brewery of Messrs. Whitbread and Co. in London, where it has been in successful operation for upwards of fifty years; and there are many others.

The sun and planet wheels were adopted about the same time, 1786, in the engines of the great establishment of the Albion Mills, for supplying London with flour, which were destroyed by fire in 1791. See Mr. Watt's note on Robison, Mech. Phil. vol. ii. p. 137, and pl. v. in the same volume. Mr. Watt has there related, that

that I cannot resist the desire of laying before you yet two other comparisons. I borrow them from one of the most distinguished correspondents of the Academy, Sir John Herschell.

The ascent of Mont Blanc from the valley of Chamouni, is considered, and justly so, as the most toilsome undertaking that a man can perform in two days. Thus, the maximum of mechanical exertion, which we are capable of making in twice twenty-four hours, is measured by the raising the weight of our body to the height of Mont Blanc. This exertion, or its equivalent, a steam-engine will make, by consuming two lbs. of coal. Watt has, then, made it appear, that the strength which a man working for a day can exert, is no more than is contained in a lb. of coal.

Herodotus relates * that the construction of the Great Pyramid of Egypt, occupied a hundred thousand men for twenty years. The Pyramid is built of calcareous stone; its cubic contents can be easily calculated; and hence the conclusion is drawn, that its weight is about thirteen millions of millions of lbs. To raise this weight to a height of a hundred and twenty-five English feet, the

most valuable assistance in the planning and construction of the mill-work and machinery, was derived from that able mechanician and engineer Mr. John Rennie, then just entering upon business, under whose direction they were executed. They, indeed, formed an era in the history of practical mechanics, and of this country, by the introduction of improved machinery. We have pleasure in recording the intimacy and attachment, which continued through life, between that afterwards widely and justly celebrated civil engineer, and Mr. Boulton and Mr. Watt.—Tr.

* See Herod. Lib. II. cap. cxxiv.—Tr.

height of the centre of gravity of the Pyramid, it would be necessary to burn, under the boiler of a steam-engine, six hundred and thirty chalders of coal. There is, among our neighbours, one foundry which I could name, which consumes a greater quantity of fuel every week.

COPYING PRESS FOR LETTERS; HEATING BY STEAM; THE COMPOSITION OF WATER; BLEACHING BY CHLORINE; EXPERIMENTS AS TO THE PHYSIOLOGICAL EFFECTS OF THE RESPIRATION OF DIFFERENT KINDS OF GAS.

Birmingham, when Watt went to settle at Soho, could reckon among the inhabitants of its neighbourhood, Priestley, whose name says everything; Darwin, the author of the Zoonomia, and of a well-known poem on the Loves of the Plants; Withering, an eminent physician and botanist; Keir, a chemist, distinguished by his Notes on his translation of Macquer, and by an interesting paper on the crystallisation of glass;* Galton, to

* He was likewise the author of another paper in the Philosophical Transactions, on the congelation of the vitriolic acid; of a treatise on the different kinds of permanently elastic fluids or gases, in 1777 and 1779; and of a fragment of a Dictionary of Chemistry in 1789-90, as well as of an Account of the Life and Writings of the well-known and eccentric philanthropist, Thomas Day, in 1791.

Mr. Keir was a gentleman of great literary as well as scientific attainments, but preferred a life of retirement in the bosom of his family, and the society of a few friends, to the allurements of the fame which must have attended him in a more public life.

Dr. Darwin had, we believe, removed from Birmingham to Lich-

whom we owe an elementary treatise on Ornithology; Edgeworth, the author of various works justly esteemed, and the father of Miss Maria, well-known to fame. Those learned men soon became the friends of the great mechanical philosopher, and nearly all of them formed an association, along with Boulton and him, under the name of the Lunar Society. So strange a name has given rise to extraordinary misapprehensions. The only meaning of it was, that the meetings were held monthly, on the evening of the full-moon, a period of the month which was fixed upon in order that the members [living in the country, on different sides of the town,] might have a light on their way home.

Each meeting of this Society gave Watt a fresh opportunity of displaying that unrivalled fertility of inventive genius, with which he was by nature gifted. "I have formed an idea," said Darwin one day to his associates, "of a duplex pen, a pen with two quills, by help of which one may write two copies of anything; which will thus, at a single operation, produce both the original and the transcript of a letter." "I believe I can find a better way of solving the problem," rejoined Watt, almost immediately; "I shall think over it to-night, and communicate my ideas to you to-morrow." By the morrow, the copying-press was invented; and even at that early period, a little model afforded the means of judging of its effects. This very

field, before the formation of the Lunar Society, but came thence to attend the meetings with Mr. Edgeworth. It is honourable to Birmingham, then a small town, to have assembled such a constellation of talent in its vicinity.—Tr.

useful machine, which has been so generally adopted in all the counting-houses in England, has recently received some modifications, the honour of which has been claimed by several artists; but I can assure you, that a description and drawing of it in its present form were given in our fellow-member's patent in the year 1780.*

Heating by steam was three years later. Watt tried it in his own house, in the end of 1783. It is true that this ingenious plan had already been pointed out by Colonel Cooke, in the Philosophical Transactions for the year 1745;† but the idea had been passed over unnoticed. Watt, at all events, deserves more than the credit of having

* For a copy of Mr. Watt's specification of this patent, with engravings of the machines, see the "Repertory of Arts and Manufactures," vol. i. 1794, p. 13.—Tr.

† I read in a work of Mr. Robert Stuart, that Sir Hugh Platte had, before Colonel Cooke, conceived the possibility of applying steam to the heating of apartments. In the "Garden of Eden" of this author, published in 1660, there is in fact mention of some plan of this sort for keeping stove-plants through the winter. Sir Hugh Platte proposes to place lids of tin, or some other metal, on the vessels in which food is dressed, and then to adapt to holes in those lids, tubes through which the steam for heating may be conducted to any place where it is wanted.—M. Arago.

For much important information on the subject of heating by steam, see Buchanan's "Treatise on the Economy of Fuel and Management of Heat, especially as it relates to Heating and Drying by means of Steam," in the preface to which, an account of Mr. Watt's proceedings in the application of this most useful principle, is given more in detail than anywhere else. A description of a machine for drying linen by steam, invented by Mr. Watt, was communicated by him to Dr. Brewster, read Dec. 21, 1824, before the Society for promoting the useful Arts in Scotland, and is to be found in the Edinburgh Encyclopædia, with an engraving copied from Mr. Watt's drawings; article Steam Drying Machine.—Tr.

brought it again into notice; he it was who first applied it; and his calculations, as to the extent of surface required for heating rooms of different sizes, were, at first, the guide to the greater number of the English engineers.

If Watt had produced, during the whole of his long career, nothing but the steam-engine with a separate condenser, the expansive engine, and the parallel motion, he would still occupy one of the first places among the small number of men whose life forms an epoch in the annals of the world. But I hold his name to be also illustriously united to the greatest and most prolific invention of modern chemistry; I mean, the discovery of the composition of water. My assertion may appear rash, for, in the numerous works which professedly treat of this principal topic in the history of science, Watt has been forgotten.* But, notwithstanding

* This is not quite correct, for, in point of fact, Mr. Watt's claims are set forth in an article on WATER, in the third edition of the Encyclopædia Britannica, published in 1797. This, from the great circulation of the work in which it appears, could hardly fail to be pretty generally known. There is a very short account of the matter in Murray's Chemistry, ed. 1806, vol. ii. p. 158; and an imperfect one in Nicholson's Chemical Dictionary, first edit. 1795, article WATER; and in Thomson's Chemistry, second edit. 1804, vol. i. p. 577; in all of which, however, the merit of the discovery is more or less attributed to Mr. Watt; (although Thomson in his Life of Cavendish, in vol. i. of the "Annals of Philosophy," does not show even that degree of correct information on the subject contained in his Chemistry.)

But, as far as the French Chemists are concerned, M. Arago's statement is literally true. Fourcroy, in his voluminous work, "Système des Connaissances Chimiques," published in 1801, appears studiously to have avoided the very mention of Mr. Watt's name, although he could not but be acquainted with his paper in the

this, I hope that you will have the goodness to follow, without prejudice, what I have to say; that you will not suffer yourselves to be debarred from making any enquiry, by authorities which, after all, are not so numerous as they are commonly supposed to be; that you will not refuse to observe how few are the authors who now-a-days derive their information from original sources; how toilsome a labour they find it to disturb the dust of libraries; how convenient, on the other hand, it seems to them to live on other men's learning, and to make the composition of a book nothing better than a mere business of editorship. The commission with which the confidence you repose in me has thought proper to entrust me, appeared to me deserving of more serious attention; I have carefully collated numerous printed papers; the whole of a voluminous authentic correspondence

Philosophical Transactions for 1784, and had met with him at Paris in 1787, in the society of his friends, Berthollet, Laplace, Monge, and Lavoisier, by all of whom Mr. Watt's merits were appreciated. Cuvier, probably misled by this authority, gives the discovery to Cavendish and Monge at p. 57 of his "Rapport Historique sur les Progrès des Sciences Naturelles," which was presented to Napoleon by the Institute in 1808, as well as in his Eloge of Fourcroy, read 1811, and of Cavendish, read 1812.

We take this opportunity of noticing that the writer of the life of Watt in Brewster's Encyclopædia, so late as 1830, has made assertions favourable to Cavendish's claims, said to be founded on a perusal of the papers he has left. His Grace the Duke of Devonshire, as the representative of Mr. Cavendish, granted permission to examine those papers. This was done by those eminent chemical philosophers, Mr. Charles Hatchett and Mr. Brande, who found nothing in them confirmatory of Mr. Cavendish's claims to the priority of the theory; which rests, as before, on the published papers of Mr. Cavendish, Mr. Watt, and Sir C. Blagden.—Tr.

still in MS.; and if, after the lapse of fifty years, I am going to vindicate for James Watt an honour which has been, on too slight grounds, accorded to one of his most illustrious countrymen, it is because I deem it expedient to show, that in the bosom of learned societies, truth is sooner or later brought to light; and, that where discoveries are concerned, there never can be any prescription.

The four pretended elements, [or simple substances], fire, air, earth, and water, of which the various combinations were said to give birth to all known bodies, are one of the many legacies bequeathed by that brilliant philosophy, which, for ages, dazzled and bewildered the noblest intellects. Van Helmont was the first to shake, though feebly, one of the principles of this ancient theory, by calling the attention of chemists to several permanent elastic fluids, several airs, which he called *gases*, and the properties of which were different from those of common air,—of the element air. The experiments of Boyle and Hooke, gave rise to still more serious doubts; they rendered it certain that common air, which is necessary for respiration and combustion, undergoes, in these two operations, remarkable changes; such a change of properties as involves the notion of composition. The numerous observations of Hales; the successive discoveries of carbonic acid by Black; of hydrogen by Cavendish; of nitric acid, oxygen, muriatic acid, sulphuric acid, and ammonia, by Priestley, finally caused the old belief in a single elemental air, to be classed among the random

and almost invariably false notions, which owe their birth to those who have the audacity to think that they are called on to explain the course of nature, by way, not of discovery, but of divination.

Amid so many remarkable discoveries, water had always retained its character of an element. The year 1776 was, at last, signalised by one of those observations which ought to lead to the overthrow of this general belief. It must be confessed, that from the same year are also to be dated those curious efforts which chemists long continued to make, to refuse to admit the natural consequences of their experiments. The observation to which I allude was made by Macquer.

This judicious chemist, having applied a saucer of white porcelain to the flame of hydrogen gas, which was quietly burning at the mouth of a bottle, observed that this flame was accompanied by no smoke, properly so called, and that it deposited no soot; that part of the saucer which the flame *licked*, became covered with little drops, quite perceptible, of a liquid like water, and which, on analysis, proved to be pure water. Here, unquestionably, was a singular result. Observe well, that it was in the middle of the flame, in that part of the saucer which it *licked*, to use Macquer's expression, that the little drops of water were deposited! This chemist, however, did not stop to enquire into this fact; he felt no astonishment at that which is really astonishing in it; he merely mentions it without comment; he does not see that he has just laid his finger on a great discovery.

Is, then, genius in the sciences of observation, to be reduced to the faculty of saying, apropos, *Why?*

In the physical world there are some volcanoes which have made only a single eruption. In like manner, in the intellectual world also, there are men, who, after a flash of genius, disappear entirely from the history of science. Such a one was Warltire, of whom the chronological order of dates leads me to mention a truly remarkable experiment. In the beginning of the year 1781, this philosopher imagined, that an electric spark could not pass through certain gaseous mixtures, without causing some change in them. An idea so novel, which was not then suggested by any analogy, and of which such happy use has since been made, ought, I think, to have led all the historiographers of science not willingly to omit to make honourable mention of its author. Warltire was deceived as to the real nature of the changes which the electrical matter produced. Luckily for himself, he foresaw that they would be attended by an explosion, and it was for this reason that he first made the experiment with a metal vessel, in which he had enclosed some common air and hydrogen gas.*

* M. Arago has omitted to state, that Mr. Warltire, in his letter dated Birmingham, 17th April, 1781, after relating his own experiments in the metal globe, goes on to say, "I have fired air in glass vessels since I saw you [Dr. Priestley] venture to do it, and have observed, *as you did*, that though the glass was clean and dry before, yet, after firing the air, it became dewy, and was lined with a sooty substance." This proves Dr. Priestley to have first made the experiment in glass vessels, as well as to have first noticed the dewy deposit.—Tr.

Cavendish very soon repeated Warltire's experiment. The certain date of his labours, (by *certain* I mean any date which can be proved by an authentic record, a memoir read to a Society, or a printed paper,) is not later than the month of April, 1783; since Priestley quotes Cavendish's observations in a paper dated the 21st of the month. From this quotation we gain only one other piece of information; viz., that Cavendish had obtained water by exploding a mixture of oxygen and hydrogen; a result already established by Warltire.

In his paper of the month of April, [1783,] Priestley added one important circumstance to those which followed from the experiments of his predecessors; he proved that the weight of the water which is deposited on the sides of the vessel at the instant of the explosion of the oxygen and hydrogen, is the sum of the weights of these two gases.

Watt, to whom Priestley communicated this important result, with the penetration of a superior mind, instantly saw in it a proof that water is not a simple substance.

"Let us now consider," he wrote to his illustrious friend, "what obviously happens in the case of the deflagration of the inflammable and dephlogisticated air. These two kinds of air unite with violence, they become red-hot, and, upon cooling, totally disappear. When the vessel is cooled, a quantity of water is found in it equal to the weight of the air employed. This water is then the only remaining product of the process, and *water*, *light*, and *heat*, are all the products.

"*Are we not, then, authorised to conclude, that water is composed of dephlogisticated air and phlogiston, deprived of part of their latent or elementary heat; that dephlogisticated or pure air is composed of water deprived of its phlogiston, and united to elementary heat and light; and that the latter are contained in it in a latent state, so as not to be sensible to the thermometer or to the eye; and if light be only a modification of heat, or a circumstance attending it, or a component part of the inflammable air, then pure or dephlogisticated air is composed of water deprived of its phlogiston and united to elementary heat?*" *

This passage, so clear, so precise, so methodical, is extracted from a letter of Watt, dated 26th April, 1783. The letter was communicated by Priestley to several of the London philosophers, and without delay transmitted to Sir Joseph Banks, President of the Royal Society, for the purpose of being read at one of the meetings of that learned body. Circumstances which I suppress, because they do not affect the present enquiry, delayed this reading for a year, but the letter remained in the archives of the Society. It figures in the 74th volume of the Philosophical Transactions, with its true date of 26th April, 1783. It is there to be

* In that chemical nomenclature which was most commonly employed when Mr. Watt wrote the above letter, hydrogen gas was called inflammable air, or phlogiston; and oxygen gas, dephlogisticated air. For a more full account of the use of those terms, (which we here explain merely in order to prevent any misapprehension on the part of the reader,) we refer to M. Arago's note on the subject, given in Lord Brougham's paper in the Appendix.—Tr.

found contained in a letter from Watt to Deluc, dated 26th November, 1783; and is distinguished by inverted commas, added by the Secretary of the Royal Society.*

I ask no pardon for this profusion of detail; you will see that nothing but the most minute comparison of dates can set the truth in its full light, and that there is here question of one of those discoveries, which do the greatest honour to the human intellect.

Among the pretenders to this prolific discovery, we are now to see the two greatest chemists of whom France and England boast. The names of Lavoisier and Cavendish will at once occur to the minds of all.

The date of the public reading of the memoir, in which Lavoisier gave an account of his experiments, and developed his views as to the formation of water by the combustion of oxygen and hydrogen, is two months later than that of Watt's letter,

* See Phil. Trans. vol. LXXIV. p. 330, and particularly Mr. Watt's note at the foot of that page. The note is as follows :—"This letter Dr. Priestley received at London, and, after shewing it to several members of the Royal Society, he delivered it to Sir Joseph Banks, the President, with a request that it might be read at some of the public meetings of the Society; but, before that could be complied with, the author, having heard of Dr. Priestley's new experiments, begged that the reading might be delayed. The letter, therefore, was reserved until the 22d of April last, [1784,] when, at the author's request, it was read before the Society. It has been judged unnecessary to print that letter, as the essential parts of it are repeated, almost *verbatim*, in this letter to M. de Luc; but, to authenticate the date of the author's ideas, the parts of it which are contained in the present letter are marked with double commas." —Tr.

preserved in the archives of the Royal Society of London, which has been already noticed.

The celebrated paper by Cavendish, entitled, "Experiments on Air,"* is still more recent; it was read on the 15th of January, 1784. You might with reason be astonished that facts so well authenticated as these, could ever have become the subject of an animated polemical controversy, did I not to hasten to call your attention to a circumstance of which I have not as yet spoken. Lavoisier declared in positive terms, that Blagden, the Secretary to the Royal Society of London, was present at his first experiments of the 24th June, 1783, and "that he informed him that Cavendish, having already tried" (at London) "to burn inflammable air in close vessels, had obtained a very perceptible quantity of water, [une quantité d'eau très sensible.]"†

Cavendish also, in his paper, repeated the communication which Blagden made to Lavoisier. According to his account, it entered into greater detail than the French chemist acknowledged. He said, that it embraced the conclusions to which the experiments led; that is to say, the theory of the composition of water.

Blagden, himself made a party in the cause,

* See Phil. Trans. vol. LXXIV. p. 119.—Tr.

† Lavoisier's memoir, in which these words occur, appears at p. 472 of that volume of the "Mémoires de l'Académie Royale des Sciences," which is entitled, "pour l'année 1781," but which was not printed till the year 1784. The paper was read on the 11th of November 1783.—Tr.

wrote, in Crell's Journal,* in 1786, a confirmation of Cavendish's assertion.

If we are to believe him, the experiments of the Parisian Academician were nothing more, than a mere verification of those of the English chemist. He declares that he told Lavoisier, that the water obtained at London, had a weight precisely equal to the sum of the weights of the two gases which were exploded. "Lavoisier," adds Blagden in conclusion, "*has told the truth, but not the whole truth.*"

A reproach such as this is severe; but, even were it well-founded, should I not greatly diminish its force, if I were to shew, that, with the exception of Watt, all those whose names figure in this narrative, were, in a greater or less degree, exposed to it?

Priestley records in detail, and as his own, experiments which prove, that the water produced by the combustion of a mixture of hydrogen and oxygen, has a weight exactly equal to that of the two gases which are burned. Cavendish, some time after, claims this result for himself, and insinuates that he had communicated it verbally to the chemist of Birmingham.

Cavendish draws from this equality of weight the conclusion, that water is not a simple substance. In the outset, he makes no mention of a paper deposited in the archives of the Royal Society, in

* Entitled, "Chemische Annalen für die Freunde der Naturlehre, Arzneygelehrtheit, Haushaltungskunst, und Manufacturen: von D. Lorenz Crell," etc. etc. Helmstädt u. Leipzig, 1786. 8vo.—Tr.

which Watt developed the same theory. It is true, that when his paper went to the press, the name of Watt was not forgotten; but it was not in the archives that the work of the illustrious engineer had been seen; the author declares that he became acquainted with it in a paper "lately read before this [the Royal] Society."* Yet it is now perfectly established, that this reading took place several months after that of the paper in which Cavendish speaks of it.

At his first entrance on this grave enquiry, Blagden states his firm resolution to clear up every thing, and, in every thing, to be precisely accurate. In fact, he does not shrink from any accusation, nor from the citation of any date, so long as there is question of ensuring to his patron and friend, Cavendish, the priority over the French chemist. As soon as he begins to speak of his two countrymen, his explanations become vague and obscure. "In the spring, [Frühjahr,]" he says, "of 1783, Mr. Cavendish communicated to me and other members of the Royal Society, his particular friends, the result of some experiments with which he had for a long time been occupied. He shewed us that out of them he must draw the conclusion, that dephlogisticated air" (or oxygen) "was nothing else than water deprived of its phlogiston," (that is to say, deprived of its hydrogen,) "and, *vice versâ*, that water was dephlogisticated air united with phlogiston. *About the same time*, [um dieselbe

* See the Phil. Trans. vol. LXXIII. p. 140.—Tr.

zeit,] the news was brought to London, that Mr. Watt of Birmingham had been induced by some observations, to form [fassen] a similar opinion."*

That expression, "*about the same time*," cannot be, to use Blagden's own words, "*the whole truth*." "*About the same time*" *proves nothing;* questions as to priority may depend on weeks, on days, on hours, on minutes. To be precisely accurate, as he had promised to be, it was indispensable that he should say, whether the verbal communication, made by Cavendish to several members of the Royal Society, preceded or followed the arrival in London of the news of Watt's labours. Can it be supposed that Blagden would not have explained so very important a circumstance, if he could have brought forward an authentic date favourable to his friend?

To complete the *imbroglio*, the foremen, the compositors, and printers of the *Philosophical Transactions*, also took part in it. Some dates in them were typographically wrong. In the detached copies of his paper, which Cavendish distributed to various learned men, I observe a mistake of one whole year. By a sad fatality,—for it is a real misfortune to give rise, unintentionally, to annoying and unmerited suspicions,—not one of those numerous errors of the press was favourable to Watt! God forbid that I should, by these remarks, intend to cast any imputation on the literary probity of those illustrious philosophers, whose

* See Blagden's paper in Crell's Journal, vol. I. 1786, p. 59. It is, on many accounts, a very remarkable one.—Tr.

names I have mentioned; they only prove, that, on the subject of discoveries, the strictest justice is all that can be expected from a rival, or a competitor, however high his reputation may already be. Cavendish would hardly listen to his men of business, when they came to consult him as to the investment of his twenty-five or thirty millions [francs]; * you can now judge, whether he felt the same indifference about experiments. It would not, then, be too much to require, that, following the example of Judges in matters of civil law, the historiographers of science should never admit as probative, any titles to property, but such as are in writing;—perhaps I should even say, but such as are registered.—Then, but not till then, would cease those contentions, continually recurring, which are usually fed by national vanity; then, in the history of chemistry, the name of Watt

* The circumstance here alluded to, is thus recorded by Dr. Thomas Thomson, in his Life of Cavendish:—"In consequence of the habits of economy which he had acquired, it was not in his power to spend the greater part of his annual income. This occasioned a yearly increase to his capital, till at last it accumulated so much, without any care on his part, that at the period of his death he left behind him nearly £1,300,000, and was the greatest proprietor in the Bank of England. On one occasion, his money in the hands of his bankers accumulated to the amount of £70,000; these gentlemen, thinking it improper to keep so large a sum in their hands, sent one of the partners to wait upon him, in order to learn how he wanted it disposed of. This gentleman was admitted, and, after employing the necessary precautions to a man of Mr. Cavendish's peculiar disposition, stated the circumstance, and begged to know whether it would not be proper to lay out the money. Mr. Cavendish dryly answered, 'You may lay it out if you please,' and left the room."—*Thomson's Annals of Philosophy*, vol. i. p. 5.—Tr.

would reassume that lofty position, which of right belongs to it.

The settlement of a question of priority, when it turns, as in the above instance, on the most careful examination of printed memoirs, and the most minute comparison of dates, assumes the character of a very demonstration. Yet, I do not consider, that this entitles me to an exemption from taking a rapid review of various difficulties, to which very able minds appear to have attached some importance.

How is it possible, I have heard it said, that in the midst of a vast vortex of business engagements; with his time taken up by a host of law-suits; every day obliged to provide, by new contrivances, for the difficulties of a manufacture yet in its infancy, Watt could have found leisure to follow, step by step, the progress of chemistry,—to make new experiments,—to propose explanations, of which the greatest masters of the science had never thought?

To this difficulty, I will give a short, but conclusive reply. I have in my hands a copy of an active correspondence, relating chiefly to subjects of chemistry, which Watt maintained, beginning in 1782, and continued in 1783 and 1784, with Priestley, Black, Deluc, Smeaton the engineer, Gilbert Hamilton of Glasgow, and Fry of Bristol.

The next objection is more plausible; it is founded in a deep knowledge of human nature.

The discovery of the composition of water, keeping pace with these admirable inventions which

we find united in the steam-engine; can we suppose that Watt would consent with cheerfulness, or at least without expressing his dissatisfaction, to see himself stripped of the honour which it ought for ever to reflect on his name?

This reasoning has the fault of being wholly without foundation. Watt never renounced the share which by right belonged to him, in the discovery of the composition of water. He caused his paper to be printed, with scrupulous care, in the Philosophical Transactions. A detailed note, authentically established the date of the giving in of the different paragraphs of that paper. What more could or ought a philosopher of the character of Watt to have done, but wait with patience for the day of justice? Yet, an awkwardness of Deluc had nearly roused our fellow-member from the forbearance natural to him. The Genevese philosopher, after having apprised the illustrious engineer of the unaccountable omission of his name in the first copy of Cavendish's paper; after having characterised this omission in terms which regard for such high reputations prevents me repeating, wrote to his friend—"I should almost advise you, considering your position, to draw from your discoveries practical results for your fortune; you should be cautious how you excite jealousy."*

* The words in the original letter are these:—"Je vous conseillerai presque, attendu votre position, de tirer de vos decouvertes des consequences pratiques pour votre fortune. Il vous faut éviter de vous faire des jaloux."—Tr.

Words such as these, wounded the high soul of Watt. "As to what you say about making myself *des jaloux*," wrote he, "that idea would weigh little; for were I convinced I had had foul play, it would either be from a contempt for the modicum of reputation which would result from such a theory, from a conviction in my own mind that I was their superior, or from an indolence that makes it more easy for me to bear wrongs than to seek redress. In point of interest, so far as connected with money, that would be no bar; for though I am dependent on the favour of the public, I am not on Mr. Cavendish or his friends."

Can it be thought that I have attached too much importance, to the theory which Watt devised, to account for the experiments of Priestley? Surely not. Those who would refuse to this theory the applause which it deserves, because it now appears to follow necessarily from the facts, forget, that the greatest discoveries of the human intellect, have been most remarkable for their simplicity. What did Newton himself do, when, repeating an experiment known fifteen centuries before his time, he discovered the composition of white light? Of that experiment he gave an explanation so perfectly natural, that it appears impossible at this day to find any other. "All that is drawn," says he, "by whatever process, out of a ray of white light, was contained in it in its compound state. The glass prism has no creative power. If the parallel and infinitely delicate ray of solar light, which falls on its first face, passes out by the

second divergently, and with a perceptible magnitude, it is because the glass separates that, which in the white ray, was, by its nature, unequally refrangible." These words are nothing else, than the literal translation of the well-known experiment of the prismatic solar spectrum. Yet this explanation had escaped an Aristotle, a Descartes, a Robert Hooke!

Let us, without leaving the subject, proceed to arguments which come still more directly to the point. The theory, which Watt formed of the composition of water, reaches London. If in the opinion of that time it is considered as simple, as self-evident, as it now appears to us, the Council of the Royal Society would not fail to adopt it. But it was not so; its strangeness even caused the truth of the experiments of Priestley to be doubted. "People even go so far," says Deluc, as to *laugh* at it, as at *the explanation of the golden tooth.*"*

* The history of this egregious imposition is given at length by Daniel Sennertus, a physician of Wittemberg, to whom it was communicated by D. Michael Doringius, who again had received it from Daniel Buretius of Vratislau. It is copied from Sennertus by the learned Dr. Antony van Dale, in his second Dissertation, "de Oraculis Ethnicorum," (pp. 474, 475, edit. Amst. 1683,) and is thence adopted by Fontenelle; who, in somewhat abridging the particulars of the story, has not failed to adorn it with the graces of his wit. We quote it in his words:—"En 1593, le bruit courut que les dents estant tombées à un enfant de Silesie, âgé de sept ans, il luy en estoit venu une d'or, à la place d'une de ses grosses dents. Horstius, Professeur en Medicine dans l'Université de Helmstad, écrivit en 1595 l'Histoire de cette dent, et prétendit qu'elle estoit en partie naturelle, en partie miraculeuse, et qu'elle avoit esté envoyée de Dieu à cet Enfant pour consoler les Chrétiens affligez par les Turcs. Figurez-vous quelle consolation, et quel rapport dent cette de aux Chrestiens,

A theory, the formation of which presented no difficulty, would assuredly have been disdained by

ny aux Turcs! En la mesme année, afin que cette dent d'or ne manquast pas d'Historiens, Rullandus en écrit encore l'Histoire. Deux ans aprés, Ingolstetterus, autre Sçavant, écrit contre le sentiment que Rullandus avoit de la dent d'or, et Rullandus fait aussitost une belle et docte Replique. Un autre grand Homme, nommé Libavïus, ramasse tout ce qui avoit esté dit de la dent, et y ajoûte son sentiment particulier. Il ne manquoit autre chose à tant de beaux Ouvrages, sinon qu'il fust vray que la dent estoit d'or. Quand un Orfevre l'eut examinée, il se trouva que c'estoit une feüille d'or appliquée à la dent avec beaucoup d'adresse; mais on commença par faire des Liures, et puis on consulta l'Orfevre." "In 1593, the rumour spread, that the teeth of a child, seven years old, in Silesia, having fallen out, a golden one had come in the place of one of the large teeth. Horstius, Professor of Medicine in the University of Helmstad, wrote, in 1595, the History of this tooth; and pretended, that it was partly natural, partly miraculous, and that it had been sent from God to this child, to console the Christians oppressed by the Turks. Fancy what consolation, or what concern this tooth could be to the Christians, or to the Turks! In the same year, in order that this golden tooth might not want historians, Rullandus wrote a second History of it. Two years after, Ingolstetterus, another philosopher, wrote against the theory which Rullandus had about the golden tooth, and Rullandus forthwith makes a fine and learned Reply. Another great man, named Libavius, collects all that had been said of the tooth, and adds his own theory. Nothing else was wanting to all those fine books, except that it should be true that the tooth was of gold. On a goldsmith examining it, he found, that it was a leaf of gold applied to the tooth with much address; but they began by making books, and *then* they consulted the goldsmith." Fontenelle, Hist. des Oracles, p. 22, edit. d'Amst. 1719. The treatise of Horstius referred to, is appended to that edition of his book, "de Natura, Differentiis, et Causis eorum qui Dormientes Ambulant," which was printed at Leipzig in 1595. A work which seems to have escaped the notice of both Van Dale and Fontenelle, is the "Tractatus de dente aureo," of Dr. Duncan Liddel, a native of Scotland, Professor of Mathematics and of Medicine in the same University with Horstius. It was printed at Hamburg in 1628.

Sennertus ends his narrative with this apposite moral:—"Quae historia omnes naturae scrutatores meritò monere debet, ne causas rei, et TO ΔIOTI prius quaerant, quàm TO 'OTI sit manifestum, et de reipsâ planè constet.—Tr.

Cavendish. Now recollect with what eagerness Blagden, under the influence of this talented man, claimed the priority for him in opposition to Lavoisier.

Priestley, on whom was to redound a considerable portion of the honour belonging to the discovery of Watt; Priestley, whose affectionate regard for the great engineer admits of no question, wrote to him, on the 29th of April 1783, "Behold with surprise and indignation, the figure* of an apparatus that has utterly ruined your beautiful hypothesis."†

In short, a hypothesis which was laughed at by the Royal Society; which made Cavendish break through his habitual reserve; which Priestley, laying aside all self-love, set himself to overturn, deserves to be recorded in the history of science as a great discovery, whatever we might at the present day be led to think of it, from knowledge now become common.‡

* In this letter, Priestley has made a rough sketch, with his pen, of the apparatus which he employed in the experiments to which he here alludes.—Tr.

† Mr. Watt, in his reply to the above letter, uses these forcible expressions;—"I deny that your experiment ruins my hypothesis. It is not founded on so brittle a basis as an earthen retort, nor on its converting water into air. I founded it on the other facts, and was obliged to stretch it a good deal before it would fit this experiment. * * I maintain my hypothesis, until it shall be shewn, that the water, formed after the explosion of the pure and inflammable air, has some other origin."—Tr.

‡ Lord Brougham was present at the public meeting, at which, in the name of the Academy of Sciences, I paid this tribute of gratitude and admiration to the memory of Watt. On returning to England, his Lordship collected valuable documents, and studied

Bleaching by means of chlorine, that admirable invention of Berthollet, was introduced into Eng-

afresh the historical question to which I have assigned so large a space, with all that superiority of discernment which is habitual to him, and that acuteness, in some sort judicial, which might have been expected from one who was Lord Chancellor of Great Britain. I owe it to a considerate kindness, of which I feel the full value, that I am enabled to make known the result, hitherto unpublished, of the labour of my illustrious fellow-member. It will be found appended to this Eloge.—M. Arago.

It is not without feelings of regret, that we find ourselves here called upon to refer to a speech, delivered by the Rev. W. Vernon Harcourt, from the chair which he temporarily occupied, as President of the British Scientific Association, lately assembled at Birmingham. But we have been informed by some of the audience, that the address was read from a written paper; and the manner in which it has since been elaborately reported, and extensively circulated in newspapers, does not permit us altogether to overlook it.

After a feeble, and almost reluctant admission of the merits of Mr. Watt, as an inventor and engineer, Mr. Harcourt proceeded to accuse M. Arago of error and misrepresentation, in having called in question what Mr. H. is pleased to term the long-established claims of Mr. Cavendish to the discovery above mentioned. As M. Arago neither was present at the meeting, nor had any friend there acquainted with the subject, or prepared to defend him, we can say little for the courtesy and liberality which prompted this public attack on an absent foreigner; more especially as, in the report so elaborately drawn up, Mr. H. has avoided all allusion to the Historical Note by Lord Brougham, whose opinion on the subject is as decided as that of M. Arago. The latter needs no aid of ours for his vindication, should he consider the provocation deserving of his notice. It will occur to every one, that when we see the Secretary of the French Academy of Sciences, (who, from his place, as well as his personal character, must be exempted from all suspicion of indifference to the intellectual glory of his nation,) abandoning the claim of priority for his most ingenious and ill-fated countryman, Lavoisier, he may be allowed to be well qualified to form an impartial estimate of the respective claims of two Englishmen, known to him only by their writings, acts, and reputation.

To Mr. H.'s main argument, founded on the character and reputation of Mr. Cavendish, we take leave to reply, that while we

land by James Watt, after his visit to Paris towards the close of the year 1786. He constructed all

entertain the highest opinion of his merits as an experimentalist and philosopher, this can never blind us to the *facts*, so clearly detailed, and established on such conclusive evidence, by M. Arago and Lord Brougham. And we beg leave to inform Mr. H., that the later and more matured opinion of Sir Humphry Davy on this question, differed little from that of every other competent judge who has examined it.

We can lay no stress on what is said of the diffidence of Mr. Cavendish. For, although we were aware of his personal shyness and retired habits, we never heard of his betraying any distrust of his scientific attainments, or any unconsciousness of their value; which alone could have any bearing on a question like the present; and when we see a deduction attempted to be forced from *his* alleged want of ambition and indifference to fame, we are called upon to observe, that it would have been but justice to have stated, how much more eminently these qualities appeared in the man, from whose merits Mr. H. is here labouring to detract. The unassuming modesty of Mr. Watt's character was conspicuous in every action of his life; it has been recognised by the most eminent men of this age; and was never more signally displayed, than in his conduct throughout this very affair, as most correctly stated by M. Arago.

The difficulty which Mr. H. professes to feel in supposing, that Mr. Watt, by *phlogiston*, meant inflammable air or *hydrogen* gas, would have been removed if he had attended to Mr. Watt's own note, (given both in the Phil. Tran. and in Lord Brougham's Historical Note,) which is to this effect:—"Previous to Dr. Priestley's making these experiments, Mr. Kirwan had proved, by very ingenious deductions from other facts, *that inflammable air was, in all probability, the real phlogiston* in an aerial form. *These arguments were perfectly convincing to me.*"

We look in vain for any other argument by which Mr. Harcourt attempts to support his rash hypothesis. No evidence whatever is produced to disprove any fact brought forward by M. Arago; and, not daring to grapple with the priority of publication, placed upon record by Mr. Watt's note in the Philosophical Transactions, which was never contradicted or called in question by Mr. Cavendish or his friends, he expends himself in tedious sophistical declamation on the merits of the respective explanations of their theories, given

the necessary apparatus, gave directions for its erection, superintended the first trials of it, and then left his father-in-law, Mr. Macgregor, to follow out the newly-discovered art. Notwithstanding all the solicitations of the illustrious engineer, our celebrated countryman persevered in refusing * to become a partner, in an enterprise which promised nothing but success, and of which it appeared that the profits must be very great.†

Scarcely had the numerous gaseous substances, which now play so conspicuous a part in the explanation of chemical phenomena, been discovered, in the latter half of the last century, than attempts were made to use them as a means of curing disease. Dr. Beddoes prosecuted this idea with sagacity and perseverance. He was enabled, by private subscriptions, to form at Clifton, near Bristol, under the designation of the Pneumatic

by the three great candidates for the discovery. We shall for the present leave him to the possession of his opinion—"alone," we believe, "in his glory!" But, since his TASTE led him to select, for the scene of his diatribe, a town justly proud of Mr. Watt's long residence near and connection with it, he can hardly be surprised at our informing him that, *there* at least, his ill-advised oration has left no impression so strong, as that of general DISGUST. —TR.

* These words are quite correct, however fabulous it may appear in the age in which we live.—M. ARAGO.

† This, no doubt, is the point of view in which it would strike abstract men of science, such as Berthollet and Arago. But in this manufacturing country, we well know that the novelty and ingenuity of a process are not of themselves sufficient to ensure a beneficial result; and, indeed, in the case of the very process in question, it happened that the first manufacturers who attempted to carry it into effect, on a large scale, were ruined by it.—TR.

Institution, an establishment, in which the therapeutic properties of all kinds of gas were carefully investigated. The Pneumatic Institution had the advantage of having for some time at its head, Humphry Davy, then a young man, just entering on his scientific career. It could also boast of numbering James Watt among its founders. The great engineer went further than this; he planned, he designed, and executed in the work-shops at Soho, the apparatus which was used for making the gases, and for administering them to patients. I find several editions of his papers on these subjects, dated in 1794, 1795, and 1796.*

The thoughts of our fellow-member were directed to this subject, in consequence of the melancholy death of several of his relations and friends, who were prematurely carried off by diseases of the chest. Injuries of the organs of respiration, in particular, appeared to Watt to admit of treatment by the specific properties of the new gases. He looked, also, for a beneficial effect from the iron or zinc, which hydrogen, when prepared in a particular way, carries along with it, in impalpable particles. In conclusion, I would add, that, among the many notices by physicians which were published by Dr. Beddoes, and among results varying in their degree of success, there is one, signed John Carmichael, of

* "Considerations on the medicinal use of factitious airs, and on the manner of obtaining them in large quantities. In two Parts, Part I. by Thomas Beddoes, M.D.; Part II. by James Watt, Esq. Bristol." 8vo. The Preface to this work is dated 1794, and it was followed, in 1795, and 1796, by "Considerations on the medicinal powers, and the production of factitious airs," by the same gentlemen.—Tr.

the complete cure of Richard Newberry, a servant, whom Mr. Watt himself caused to inhale a mixture of steam and carbonic acid gas. The disease was spitting of blood. Though I readily acknowledge my total incompetence to judge of a matter of this kind, I yet may be permitted to express my regret, that a system which numbered among its adherents, a Watt and a Jenner, should now be altogether abandoned; while yet no series of experiments can be mentioned, which directly contradict those of the Pneumatic Institution of Clifton.*

WATT IN PRIVATE LIFE; PARTICULARS OF HIS LIFE AND CHARACTER; HIS DEATH; THE NUMEROUS STATUES ERECTED TO HIS MEMORY; REFLECTIONS.

Watt had married, in 1764, his cousin, Miss Miller. She was an accomplished person, whose superior intellect, invariable mildness, and cheerfulness of disposition, very soon rescued the great engineer from that indolence, despondency, and misanthropy, which a nervous illness, and the injustice of men, threatened to render fatal. But for Miss Miller, Watt might never have made public his fine inventions. Of this marriage, there were born four children, two sons and two daugh-

* At so early a period as twenty years before the Pneumatic Institution of Bristol came into existence, Watt had applied his knowledge of chemistry and mineralogy to the improvement of a pottery, which, in concert with some friends, he had established at Glasgow, and of which he continued a partner till the close of his life.—M. Arago.

ters.* Mrs. Watt died† in child-bed of a third son, still-born. Her husband was at that time engaged in the north of Scotland, with the plan of the Caledonian Canal. Would that I might here transcribe, in all their simple beauty, some lines of the journal in which he daily recorded his inmost thoughts, his fears, his hopes! Would that you could see him, after this heavy affliction, pausing on the threshold of that home, where "HIS KIND WELCOMER" awaited him no more; unable to summon courage to enter those rooms, where he was never more to meet "THE COMFORT OF HIS LIFE!" Possibly, so faithful a picture of a very deep sorrow might at last put to silence those obstinate theorists, who, without being struck by the thousands of instances to the contrary, do yet refuse qualities of the heart to every man whose intellect has been fostered by the fertile, sublime, and imperishable truths of the exact sciences!

After continuing for some years a widower, Watt was once more so fortunate as to find, in Miss Macgregor, one whose various talent, soundness of judgment, and strength of mind, rendered her a companion worthy of himself.‡

On the expiration of the patent which Parliament had granted him, Watt, in the beginning of the year 1800, retired altogether from business. His

* Two of these died in infancy; a daughter married Mr. Miller of Glasgow, and has left issue. The present Mr. James Watt is the gentleman mentioned by M. Arago in various parts of this Eloge.—TR.

† 24th September, 1773.—TR.

‡ Mrs. Watt (Miss Macgregor) died in 1832, at a very advanced age. She had the misfortune to be preceded by the two children, the issue of her marriage with Mr. Watt.—M. ARAGO.

two sons succeeded him. Under the enlightened superintendence of the present Mr. Boulton, and of the young Messrs. Watt, the Soho works continued to prosper, and even received new and important additions. They still hold the first place among the manufactories of steam-engines in England.* Gregory Watt, the son of our fellow-

* In speaking of the Engine Establishment of Soho, it would be improper to omit mention of the able engineers who assisted in carrying it on. Mr. Watt, in his note upon Robison, Mech. Phil. vol. ii. pp. 140-141, bears testimony to the merits of Mr. William Murdock, and some valuable improvements which he introduced. Mr. Murdock is still better known to the world by his invention of "the Application of the Gas from Coal to economical purposes;" see his Paper in the Phil. Trans. for 1808, pp. 124-132; for which the Society presented him with their large Rumford gold medal. He proved a most able and zealous assistant in the introduction of the engines into Cornwall; and, afterwards, in the construction and carrying on of the works at Soho foundry. Mr. Murdock made the first locomotive engine ever applied to the drawing of carriages, in or about the year 1784, upon the principle set forth in the fourth article of Mr. Watt's specification of 1769. "*I intend in many cases to employ the expansive force of steam to press on the pistons. * * * In cases where cold water cannot be had in plenty, the engines may be wrought by this force of steam only, by discharging the steam into the open air after it has done its office.*" The working model of Mr. Murdock's engine is yet in his possession, and a friend of ours still lives, who, in 1784, saw it drive a small waggon round the room. This was in Mr. Murdock's house at Redruth in Cornwall, where it was shewn to many; and, among others, to Mr. Richard Trevithick, who, in 1802, took out a patent for an engine to be applied to the driving of carriages, using the same principle, with variations. Mr. Murdock still lives, in very advanced years; and will, we trust, be able to enjoy this association of his name with that of his venerated master and friend.

Mr. John Southern, who, after Mr. Watt's retirement, conducted for many years the business of the drawing-office at Soho, and died in 1815, was an able mathematician and engineer. We have from him a small treatise on Aërostatic Machines, in 1785, and a Letter on the Elasticities of Steam under different pressures, printed in Robison's Mech. Phil. vol. ii. p. 160-175.

member by his second marriage, had begun his career in the most brilliant manner, by literary compositions and geological works. He died in 1804, at the age of twenty-seven, of a disease of the chest. This afflicting event quite overpowered the great engineer. The tender care of his family and friends could with the greatest difficulty restore some comfort to a half-broken heart. It has been thought, that this too well-founded sorrow may serve to account for the almost total silence, which Watt preserved during the latter years of his life.* I am far from denying that it may not

Mr. Peter Ewart, now engineer to the Admiralty at Woolwich, rendered occasionally the aid of his great skill and ingenuity. And we must not pass over the name of Mr. James Lawson, late at the head of the mechanical department of the Mint on Tower-hill; nor those of Messrs. William and Henry Creighton, brought up at Soho, whose talents were creditable both to themselves and to the establishment. The last three have been dead some years.—Tr.

* M. Arago has not been correctly informed on this subject. Mr. Watt's remarkable activity of mind was not impaired, nor his interest in the pleasures of literature and society destroyed, by the melancholy death of his son; and neither his conversation nor correspondence betrayed any approach to that silence, which, as recorded in the text, seems so extraordinary. These are the words of one who knew him well, and saw him often;—"He preserved, up almost to the last moment of his existence, not only the full command of his extraordinary intellect, but all the alacrity of spirit, and the social gaiety which had illuminated his happiest days. His friends in this part of the country [Edinburgh] never saw him more full of intellectual vigour and colloquial animation—never more delightful or more instructive, than in his last visit to Scotland in 1817." See the Notice by Lord Jeffrey, given in the Appendix.

To show still more particularly the nature of Mr. Watt's feelings on the occasion in question, we add the following extracts from two of his private letters in our possession. They were addressed to his cousin, the late Robert Muirheid, Esq. of Croy-Leekie, with whom Mr. Watt maintained a constant and affectionate correspondence.

have been without its effect; but there is no need for having recourse to extraordinary causes, when we read in a letter, dated so far back as 1783, written by Watt to his friend Dr. Black :—" For my own part, I have little ambition, or desire to

HEATHFIELD, *January 26th*, 1805.

* * " I perhaps have said too much to you and Mrs. Campbell on the state of my mind. I therefore think it necessary to say that *I am not low spirited*, and were you here you would find me as cheerful in the company of my friends as usual; my feelings for the loss of poor Gregory are not passion, but a deep regret that such was his and my lot.

" I know that all men must die, and I submit to the decrees of Nature, I hope with due reverence to the Disposer of events. Yet one stimulus to exertion is taken away, and somehow or other I have lost my relish for my usual avocations. Perhaps time may remedy that, in some measure; meanwhile, I do not neglect the means of amusement which are in my power."

HEATHFIELD, *April 8th*, 1805.

* * " It is rather mortifying to see how easily the want of even the best of us is dispensed with in the world, but it is very well it should be so. We here, however, cannot help feeling a terrible blank in our family. When I look at my son's books, his writings, and drawings, I always say to myself, where are the mind that conceived these things, and the hands that executed them? In the course of nature, he should have said so of mine; but it was otherwise ordered, and our sorrow is unavailing. As Catullus says,

—— " Nunc it per iter tenebricosum,
Illuc, unde negant redire quemquam.
At vobis male sit malæ tenebræ
Orci, quæ omnia bella devoratis!"

" But Catullus was a heathen; let us hope that he (G.) is now rejoicing in another and a better world, free from our cares, griefs, and infirmities. Some one has said, I shall not wholly die; and Gregory's name, his merits, and virtues, will live at least as long as those do who knew him. You are not from this to conceive that we give way to grief; on the contrary, you will find us as cheerful as we ought to be, and as much disposed to enjoy the friends we have left as ever; but we should approach to brutes if we had *no* regrets." Mr. Watt, at the date of these letters, had entered on his seventieth year, a period after which great mental exertions are rarely made.—TR.

publish any of the experiments I have made;" when we find, elsewhere, these words, truly remarkable as coming from a man who has filled the world with his fame, "I know only two pleasures, idleness and sleep." These slumbers, it need hardly be observed, were very light. I may add, that the least excitement was sufficient to rouse Watt from his favourite indolence. Every object that was presented to his notice, gradually received in his imagination changes of form and construction, of such a kind as to render them susceptible of important applications. Those conceptions were, in many cases, for want of an occasion to call them out, lost to the world. The following anecdote will explain my meaning.

A company had erected at Glasgow, on the right bank of the Clyde, large buildings and powerful engines, for bringing water into all the houses in the town. When this labour was completed, it was found that there existed near the opposite bank, a spring, or rather a sort of natural filter, which supplied water of evidently better quality. To change the site of the establishment was never even proposed; so they thought of laying, across the bottom of the river, an inflexible suction-pipe, the mouth of which was meant always to lie in the clear water; but it seemed that the construction of a flooring, fitted to support such a pipe, on a muddy and shifting bed, full of inequalities, and always covered with water to a depth of several feet, must require too great an outlay. Watt was consulted, and his answer was given in an instant. Some days previously, seeing a lobster on the table,

he had tried and found out how mechanical art could, of iron, make a machine with joints, which should have all the flexibility of the tail of the shell-fish. It was, then, an articulated suction-pipe, capable of accommodating itself to all the actual and possible bendings of the bed of the river, that he proposed; just an iron lobster's tail, two English feet in diameter, and a thousand feet in length; which, after the plans and drawings of Watt, the Glasgow company got executed with complete success.*

Those who had the happiness of being personally acquainted with our fellow-member, have no hesitation in affirming, that his merits as a philosopher were even exceeded by the good qualities of his heart. A child-like candour, the greatest simplicity of manners, a love of justice carried even to an extreme, an unwearied benevolence,—these have left remembrances in Scotland and England that can never be effaced. Watt, of a disposition so placid, so gentle, became ruffled whenever, in his presence, an invention was not attributed to its real author; and, above all, when any base flatterer endeavoured to enrich him at the expense of others.† In his eyes, scientific discoveries were the greatest of blessings. He willingly gave whole hours to discussion, if the ob-

* An account of this flexible water-pipe, accompanied by an engraving from the drawing sent by Mr. Watt, was communicated by Sir John Robison to the Edinburgh Philosophical Journal in 1820. See vol. iii. p. 60.—Tr.

† For a vivid and pleasing portraiture of these characteristics of Mr. Watt's mind, see the eloquent speech by Lord Brougham, given in the Appendix.—Tr.

ject was to do justice to modest inventors, who had been robbed of their rights by piracy, or even forgotten by a thankless public.

Watt's powers of memory might have been instanced as marvellous, even when compared with all that has been related of this faculty, in the case of the most gifted individuals. Yet the extent of that memory was its least merit; it took possession of all that was of any value, and utterly rejected, as if by instinct, that superfluous matter which it would have been useless to retain.

The variety of our fellow-member's information would be quite incredible, were it not attested by many eminent men. Lord Jeffrey happily characterised the intellect, at once powerful and subtle, of his friend, when, in an eloquent notice,* he compared it to the trunk, so wonderfully contrived, which the elephant employs, with equal ease, to pick up a straw or to rend an oak.

In the preface to the Monastery, Sir Walter Scott speaks of his countryman in the following terms: "There were assembled about half a score of our Northern Lights. * * Amidst this company stood Mr. Watt, the man whose genius discovered the means of multiplying our national resources to a degree perhaps even beyond his own stupendous powers of calculation and combination; bringing the treasures of the abyss to the summit of the earth —giving the feeble arm of man the momentum of an

* See Lord Jeffrey's Notice of Mr. Watt's character, given in the Appendix.—Tr.

Afrite—commanding manufactures to arise, as the rod of the prophet produced water in the desert—affording the means of dispensing with that time and tide which wait for no man—and of sailing without that wind which defied the commands and threats of Xerxes himself. This potent commander of the elements—this abridger of time and space—this magician, whose cloudy machinery has produced a change on the world, the effects of which, extraordinary as they are, are, perhaps, only now beginning to be felt—was not only the most profound man of science—the most successful combiner of powers, and calculator of numbers, as adapted to practical purposes—was not only one of the most generally well-informed, but one of the best and kindest of human beings.

"There he stood, surrounded by the little band I have mentioned of Northern literati, men not less tenacious, generally speaking, of their own fame and their own opinions, than the national regiments are supposed to be jealous of the high character which they have won upon service. Methinks I yet see and hear what I shall never see or hear again. In his eighty-second year, the alert, kind, benevolent old man, had his attention alive to every one's question, his information at every one's command.

"His talents and fancy overflowed on every subject. One gentleman was a deep philologist,—he talked with him on the origin of the alphabet as if he had been coeval with Cadmus; another a celebrated critic,—you would have said the old man had studied political economy and belles-let-

tres all his life;—of science it is unnecessary to speak, it was his own distinguished walk. And yet, Captain Clutterbuck, when he spoke with your countryman, Jedediah Cleishbotham, you would have sworn he had been coeval with Claverse and Burley, with the persecutors and persecuted, and could number every shot the dragoons had fired at the fugitive Covenanters. In fact, we discovered that no novel of the least celebrity escaped his perusal, and that the gifted man of science was as much addicted to the productions of your native country, in other words, as shameless and obstinate a peruser of novels, as if he had been a very milliner's apprentice of eighteen."

Had our fellow-member been ambitious of it, he might have made himself a name among novelists. In the company of his intimate friends, he rarely failed to improve on the terrible, pathetic, or ludicrous anecdotes which he heard related. The minute details of his stories, the proper names with which he interspersed them, the exact descriptions of the castles, country-houses, forests, and caverns where the scene was successively laid, gave to these improvisations so great an air of truth, that one would have been quite sorry to experience the least emotion of incredulity. One day, however, Watt found some difficulty in extricating his *dramatis personæ* from the labyrinth in which he had imprudently involved them. One of his friends detected it, by the unwonted number of pinches of snuff, which the narrator was making a pretext for frequent pauses, and for gaining time to reflect.

So he asked him this indiscreet question: "Now, pray, are you telling us a story of your own invention?" "How could you ever doubt it?" with naïveté replied the old man, "for twenty years, since I first had the pleasure of spending my evenings with you, I have done nothing else. Is it really possible that you wanted to make me a rival of Robertson or of Hume, while my utmost ambition was limited to treading, at a humble distance, in the footsteps of the Princess Scheherazade, of the Thousand and One Nights?"

Every year, during a short excursion to London, or other towns nearer Birmingham, Watt examined in detail everything new that had appeared since his last visit. I do not except even the exhibition of the Industrious Fleas, or a puppet-show; for the mighty engineer went to see these with all the eager delight of a school-boy. In following, even at this day, the track of those annual tours, we should, in more than one place, find luminous traces of the passage of Watt. At Manchester, for instance, we should see the hydraulic ram, at the suggestion of our fellow-member, employed to raise the condensing water in a steam-engine, up to the feed-cistern of the boiler.

Watt usually resided on the estate of Heathfield, near Soho, which he had acquired about the year 1790. The religious respect with which my friend, the present Mr. James Watt, regards all that recalls the remembrance of his father, procured for me, in 1834, the satisfaction of finding the library and furniture at Heathfield, in the same

state in which they were left by the great engineer. Another property on the picturesque banks of the river Wye, in Wales, presents to travellers numerous proofs of the enlightened good taste of Watt and his son, in the improvement of roads, planting, and agricultural labours of every description.

The health of Watt had strengthened with advancing years. His intellectual faculties retained all their vigour even to the last moment. He once thought that they were beginning to fail; and, true to the device which he had chosen for his seal, (an eye, with the motto OBSERVARE,) he determined to clear up his doubts by observing himself. He was then seen, at more than seventy years of age, seeking for some kind of study to try himself by, and lamenting that he could find no subject entirely new, for his intellect to exercise itself upon. At last, calling to mind the Anglo-Saxon language, and that it is one of some difficulty, he makes Anglo-Saxon the experimental test which he wanted; and the facility with which he masters it, shews him how little ground there was for his apprehensions.

Watt devoted the last moments of his life to the construction of a machine intended to copy, with despatch and mathematical exactness, pieces of statuary and sculpture of all dimensions. This machine, of which I trust the arts are not to lose the benefit, must have been very considerably advanced. Several of its performances, which even then were very satisfactory, are to be seen in the cabinets of various amateurs in England and Scot-

land. The great engineer, when he presented them, gaily remarked, that they were the first attempts of a young artist entering on his eighty-third year.

Of this eighty-third year, he was not permitted to see the close. In the very early part of the summer of 1819, alarming symptoms set all the efforts of medical men at defiance. Watt was quite aware of his situation. "I am very sensible," he said to the numerous friends who came to see him, "I am very sensible of the attachment which you shew me, and I hasten to thank you for it, as I have now come to my last illness." His son appeared to him not sufficiently resigned; and every day he sought some new pretext for calling his attention, with gentle and affectionate tenderness, to "all those topics of consolation which he ought to recognise, in the circumstances, under which an inevitable event was about to take place." This sad event did in fact take place, on the 25th of August, 1819.

Watt was interred in the parochial church of Heathfield, at Handsworth, in the county of Stafford, near Birmingham. The present Mr. James Watt, whose eminent talents and noble sentiments had, for nearly five and twenty years, adorned his father's life, has there erected an elegant Gothic Chapel, in the centre of which is placed an admirable marble statue, executed by Chantrey, and which is a faithful representation of the noble features of the old man.*

* The thoughtful cast of his features was so remarkable, as to draw from his friend, Mr. Richard Sharp, of conversational fame, the

Another marble statue, from the hand of the same sculptor, has also been placed by filial piety in one of the halls of that eminent University, where, in his earlier days, the artist, yet unknown, and exposed to the molestation of the corporate bodies, met with encouragement at once so flattering, and so well deserved.* Greenock has not forgotten that Watt was born there. The inhabitants of that town are getting a marble statue of the illustrious mechanician executed at their own expense. It is to be placed in a handsome Library, built on a site which Sir Michael Shaw Stewart gave for the purpose; where, also, are to be brought together the books which were the property of the town, and the collection of scientific works which Watt had presented to it during his life.† This building has already cost £3500, which large expense has been defrayed by the liberality of the present Mr. Watt.‡ A fine colossal bronze statue,

playful observation, "I never look at Mr. Watt's countenance without fancying I behold the personification of abstract thought."—Tr.

* Mr. Watt's memory has also been perpetuated in the same University, which his name has honoured, by the annual Prize which he there founded, for the best Essay on some subject connected with Science or the Arts.—Tr.

† The statue has now been placed in the Library; and on the pedestal is an inscription by Lord Jeffrey.—Tr.

‡ Mr. Watt, in offering his first donation of £2000, stated "that it was to be employed in the erection of a building for a Library, of which the statue should form the principal ornament; and that he left it open to others to add to that sum, if their views should extend further, so as to combine with it reading-rooms, and a house or apartments for the Librarian." This was subsequently confirmed by Mr. Watt, upon making a further donation, and powers to the effect of allowing such additions to be made, were granted in the charter. —Tr.

placed on a handsome granite pedestal, and commanding one of the angles of George Square in Glasgow, displays to the eyes of all, what pride this metropolis of Scottish industry feels, in having been the cradle of Watt's discoveries. Lastly, the portals of Westminster Abbey opened at the voice of an imposing body of subscribers; and a colossal statue of our fellow-member, of Carrara marble, a master-piece by Chantrey, and bearing on its pedestal an inscription by Lord Brougham,* has been, for some years, one of the principal ornaments of that Pantheon of England. No doubt,

* The inscription is as follows:—

NOT TO PERPETUATE A NAME
WHICH MUST ENDURE WHILE THE PEACEFUL ARTS FLOURISH
BUT TO SHEW
THAT MANKIND HAVE LEARNT TO HONOUR THOSE
WHO BEST DESERVE THEIR GRATITUDE
THE KING
HIS MINISTERS AND MANY OF THE NOBLES
AND COMMONERS OF THE REALM
RAISED THIS MONUMENT TO

JAMES WATT

WHO DIRECTING THE FORCE OF AN ORIGINAL GENIUS
EARLY EXERCISED IN PHILOSOPHIC RESEARCH
TO THE IMPROVEMENT OF
THE STEAM ENGINE
ENLARGED THE RESOURCES OF HIS COUNTRY
INCREASED THE POWER OF MAN
AND ROSE TO AN EMINENT PLACE
AMONG THE MOST ILLUSTRIOUS FOLLOWERS OF SCIENCE
AND THE REAL BENEFACTORS OF THE WORLD
BORN AT GREENOCK MDCCXXXVI
DIED AT HEATHFIELD IN STAFFORDSHIRE MDCCCXIX.

there is a little affectation, in uniting, on one monument, the illustrious names of Watt, Chantrey, and Brougham; but this, I, at least, could never censure; glory to the people who thus seize every occasion of honouring their great men!

I have now enumerated five great statues, erected, within a very short space of time, to the memory of Watt. Yet, strange to say, this homage paid by filial piety and public gratitude, has excited the spleen of some narrow-minded persons, who, remaining stationary themselves, fancy that they can arrest the march of ages. If we were to believe what they say, warriors, magistrates, statesmen, (I must admit that they have not dared to say *all* statesmen), would be entitled to statues. I know not whether Homer, or Aristotle, or Descartes, or Newton, would appear, to our modern Aristarchs, to merit even a bust; and most assuredly they would refuse the plainest medallion to a Papin, a Vaucanson, a Watt, an Arkwright, and other mechanicians, unknown, perhaps, to a certain circle, but whose renown will, from age to age, continue to increase with the progress of knowledge. When heresies such as these dare to shew themselves in the broad light of day, we must no longer disdain to combat them. It is not without reason that the public has been styled a sponge for imbibing prejudices; and prejudices are like noxious weeds; —the slightest effort is sufficient for their extirpation, if they are taken when they first begin to sprout; but they offer resistance when they have been allowed time to grow, to spread, and to grasp

in their manifold tendrils all that was within their reach.

If this discussion should wound the self-love of any individuals, I would observe that it has not been unprovoked. Have the literary men of our own time ever complained, that they see none of the great authors whose inheritance they cultivate, figuring in those long ranks of colossal statues, which are proudly raised, by public authority, on our bridges and in our public squares? Do they not rather know, that monuments such as these are fragile; that tempests shake and overthrow them; that frosts are sufficient to wear away their outlines, and to reduce them to shapeless blocks?

The statuary, the painting which they assign to them, is the art of printing. Thanks to this admirable invention, when works which are the offspring of science or imagination have any real merit, they may set at defiance the injuries of time, and the revolutions of states. Neither fiscal regulations, nor the restless anxieties and terrors of despotism, can ever prevent these productions from crossing the most strictly guarded frontier. A thousand ships transport them, under every form, from one hemisphere to the other. They furnish materials for thought, at once in Iceland and Van Diemen's Land; they are read at the fireside of the humble cottage, they are read in the dazzling society of the palace. The author, the artist, the engineer, is known and appreciated by the whole world,—by all that is in man most dignified and

noble,—by feeling, thought, and intellect. Very much mistaken would that man be, who, placed on the stage of such a theatre, should detect himself indulging the wish that his form and features, represented in marble or bronze, although by the chisel of a David, should ever be exposed to the gaze of idle loungers. Honours such as these, I repeat, a philosopher, author, or artist ought not to envy; but neither ought they, on any account, to suffer themselves to be called unworthy of them. Such, at least, is the moral suggested to me by the discussion which I am about to submit to your enlightened understanding.

Is it not a circumstance truly marvellous, that the haughty pretensions against which I contend, should have been brought forward, just in regard to five statues which have not cost the public purse a single farthing? But far from me be all thought of profiting by this want of judgment. I prefer considering the question in its general bearing, such as it has been stated; viz. the pretended pre-eminence of arms over literature, science, and the arts; for it cannot be disguised, that, if magistrates and statesmen have been associated with warriors, it is only as a passport.

The shortness of the time which I am permitted to devote to this discussion, obliges me to proceed systematically. In order that my sentiments may not be mistaken, I take this early opportunity of very openly proclaiming, that I look upon the independence and liberties of a nation as the highest of blessings; that to defend them against either a

foreign invader or a civil foe, is the first of duties; that to have maintained them at the price of one's own blood, is the strongest of all claims on the public gratitude. Raise, oh raise your splendid monuments to the memory of the soldiers who fell on the glorious ramparts of Mayence, or gained immortal fame in the fields of Zurich and Marengo, and, assuredly, my contribution will be offered with no tardy hand; but ask me not to do violence to my reason, and to the feelings which nature has implanted in the heart of man,—think not that I can ever agree to place all military services on a parity of merit.

What Frenchman of right feeling, even in the time of Louis XIV., would have sought for an example of valour, either in the horrible scenes of the Dragonnades, or in the whirlwinds of flame which devoured the towns, the villages, the fertile plains of the Palatinate?.*

It was but lately, that our brave soldiers, after infinite prodigies of endurance, skill, and valour, as they forced their way into Saragossa, then half in ruins, reached the door of a church where the

* "Towards the close of the year 1684," says Voltaire, "and in the beginning of 1685, whilst Louis XIV., always well armed, feared none of the neighbouring nations, the troops were sent into all the towns, and all the country-houses where there were most Protestants; and as the dragoons, at that time under very bad discipline, were those who committed the greatest excesses, this kind of slaughter was called the Dragonnade."—*Age of Louis XIV.* chap. 32. For an account of the devastation of the Palatinate, see the same History, chap. 15. The guilt and shame of those disgraceful cruelties, seem to be due equally to Louvois and Louis; the minister who suggested, and the monarch who permitted their infliction.—Tr.

preacher was thundering in the ears of the resigned multitude, these magnificent words:—"Spaniards! I am about to celebrate your funeral rites!" I know not whether, at that moment, the true friends of our national glory, on balancing the different deserts of the victors and the vanquished, would not gladly have reversed their positions!

I have no objections that the question of morality be entirely set apart. Put into the crucible of conscientious criticism, the personal claims of certain gainers of battles, and believe me, that after having made due allowance for chance, a sort of ally which, because it is silent, is never taken into account, very many pretended heroes will appear to you little deserving of that pompous title.

Were it deemed necessary, I should not shrink from a detailed enquiry; I, who, in a career altogether academical, can have had few opportunities of collecting exact documents on such a subject. I could, for instance, cite from our own annals, a modern battle, a battle which was won, which is described in the official report as an event that was foreseen, and prepared for with the most consummate skill and deliberation; while, in reality, it was gained by a rapid and spontaneous charge of the soldiers, without any orders from the commander-in-chief, to whom the honour of it has accrued,—without his having been either present, or aware of what was going on.

To defend my testimony from the vulgar reproach of incompetence, I shall adduce some mili-

tary men themselves, in support of the philosophical position which I maintain. You will see, with what enthusiastic and enlightened discernment, they appreciated the labours of the intellect; you will see, that in their inmost thoughts, the exertions of mind never occupied a secondary rank. Restrained, of necessity, within narrow bounds, I shall endeavour to compensate for the want of numbers and novelty, by the splendour of their fame; I shall cite Alexander, Pompey, Cæsar, and Napoleon!

The Macedonian conqueror's admiration for Homer, is matter of history. At his request, Aristotle took charge of revising the text of the Iliad. This corrected copy became his favourite book; and when, in the heart of Asia, among the spoils of Darius, a magnificent casket adorned with gold, pearls, and precious stones, appeared to excite the cupidity of his principal officers, "Let it be reserved for me," exclaimed the victor of Arbela, "I will keep my Homer in it, for he is my best and most faithful counsellor in my military affairs; it is, besides, right, that the richest production of the arts should be used to preserve the most precious work of the human intellect." *

The sack of Thebes had already, still more signally, displayed Alexander's unbounded respect and admiration for literature. One family alone,

* "Alexander Magnus, inter spolia Darii Persarum regis unguentorum scrinio capto, quod erat auro gemmisque ac margaritis pretiosum, varios ejus usus amicis demonstrantibus, imò Herculo, inquit, librorum Homeri custodiæ detur; ut pretiosissimum humani animi opus, quàm maximè diviti opere servaretur."—*Plin. Nat. Hist.* lib. VII. cap. XXIX. See also Plut. in Alex. Vit.—Tr.

in all that populous city, escaped death or slavery; it was the family of Pindar. One house alone was left standing, amid the ruins of temples, palaces, and private dwelling-houses; it was the house where Pindar was born,* and not that of Epaminondas!

When, after having ended the war with Mithridates, Pompey went to pay a visit to the celebrated philosopher Posidonius, he forbade the lictors to knock at the door with their staves, as was usually the custom. "Thus," says Pliny, "the fasces of him, who had beheld the east and west laid prostrate at his feet, were lowered before the humble abode of a philosopher."†

Cæsar, whom literature also can claim for her own, lets us see clearly, in a score of passages of his immortal Commentaries, what comparative rank the different kinds of talent with which nature had so liberally endowed him, held in his own estimation. How concisely, how rapidly he writes, when relating skirmishes and battles! See, on the other hand, whether he thinks any detail superfluous, in the description of the extemporary bridge by which his army crossed the Rhine. The reason is, that here, success depended entirely on the conception, and the conception was entirely

* "Idem Pindari vatis familiæ penatibusque jussit parci, cum Thebas caperet."—*Plin. N. H.* VII. XXIX.—Tr.

† "Cn. Pompeius, confecto Mithridatico bello, intraturus Posidonii sapientiæ professione clari domum, fores percuti de more a lictore vetuit, et fasces lictorios januæ submisit is, cui se oriens occidensque submiserat."—*Plin. N. H.* VII. XXX.—Tr.

his own. It has also been remarked,* that the share which Cæsar preferably ascribes to himself in the events of war, and of which he appears most proud, is a moral influence. "Cæsar harangued his army," almost always begins the description of a victory; "Cæsar did not arrive in time to address his soldiers, and exhort them to fight bravely," usually accompanies the recital of a surprise or sudden defeat. He seems constantly to take a pride in sinking the general in the orator; "and truly," says the judicious Montaigne, "his tongue has on many occasions done him very signal service!" †

But now, at once, and without even pressing on your attention that well-known exclamation of Frederick the Great, "I would rather have written Voltaire's Age of Louis XIV., than have gained a hundred battles!" I come to Napoleon. As I must hurry rapidly on, I shall not dwell either on the celebrated proclamations, written in the shadow of the Pyramids of Egypt, by the *Member of the Institute*, Commander-in-chief of the army of the East; or on the treaties of peace, wherein monu-

* By Montaigne.—"Il ne s'arreste si volontiers en nul endroit de ses faits, qu'à nous representer la subtilité de ses inuentions, en telle sorte d'ouurages de main. J'y ay aussi remarqué cela, qu'il fait grand cas de ses exhortations aux soldats auant le combat; car où il veut montrer auoir esté surpris, ou pressé, il allegue tousiours cela, qu'il n'eut pas seulement loisir de haranguer son armée."—See the ingenious "Obseruations sur les moyens de faire la guerre de Julius Cesar," Essais, p. 481, ed. 1640.—Tr.

† "De vray, sa langue luy a faict en plusieurs lieux de bien notables seruices!"—Tr.

ments of art and science were made the ransom of vanquished nations; or on the high esteem which the General, after he became Emperor, never ceased to testify to a Lagrange, a Laplace, a Monge, and a Berthollet; or on the wealth, or the honours, with which he loaded them. An anecdote, not generally known, will more directly serve my purpose.

Every one must remember the decennial prizes. The four Classes of the Institute had sketched a rapid outline of the progress of science, literature, and the arts. The presidents and secretaries were to be summoned, in succession, to read them to Napoleon, in the presence of the great dignitaries of the empire, and of the Council of State.

On the 27th February, 1808, the turn of the French Academy arrives. As may be supposed, the attendance is on this day even more than usually numerous; for who does not hold himself to be a very competent judge in matters of taste? Chenier speaks. He is listened to with devout attention; when the Emperor suddenly interrupts him, and, laying his hand on his heart, his frame bent forward and his voice broken by evident emotion, "It is too much, gentlemen," he exclaimed, "it is too much; you overpower me; I can find no words to express my gratitude!"

I leave you to imagine the utter astonishment of the numerous courtiers who witnessed this scene;—men who, from one degree of adulation to another, had come, at last, to say to their master, without his

testifying surprise, "When God had created Napoleon, He felt need of rest!"

But what, then, were those words, which came so directly home to the heart of Napoleon? They were these:—"In the camp, where, far from the calamities at home, the glory of the nation was maintained inviolate, there arose a new kind of eloquence, unknown, till then, to modern nations. It must even be acknowledged, that when in ancient authors we read the orations of the most famous generals, we are often tempted to admire in them only the genius of the historians. Here there can be no such doubt; the monuments themselves exist; history has only to collect them. It was from the army in Italy, that those admirable proclamations went forth, by which the victor of Lodi and Arcola created, at once, a new art of war, and the military eloquence of which he will for ever remain the model."

On the 28th of February, the day after the famous meeting of which I have just given an account, the Moniteur, *with its accustomed fidelity*, published a report of the Emperor's reply to the discourse of Chenier. It was cold, studied, unmeaning; it had, in a word, all the character,—some would say, all the qualities,—of an official document. As for the incident which I have just related, it was not even mentioned. A miserable concession to the dominant opinions,—to the sensibilities of the military staff! But the fact was not the less certain, that this master of the world,

yielding for a moment to his own heartfelt emotions, had, to use the expression of Pliny, lowered his fasces before that literary dignity, which a body of learned men awarded to him!

These reflections on the comparative merits of studious men and military men, although they may have been suggested to me, principally, by what is said, and done, under our own observation, are not uncalled-for in the native land of Watt. I lately travelled through England and Scotland. The kindness which I experienced, authorised me to put questions so dry, so searching, so direct, as, in any other circumstances, could be allowed only to the chairman of a commission of enquiry. Even then, much occupied with the obligation I should be under on my return, of expressing my thoughts of the illustrious mechanician; even then, oppressed by a sense of the solemnity of that assembly which I now address, I had prepared this question, "What is your opinion of the influence which Watt has exercised on the wealth, the power, the prosperity of England?" I do not exaggerate when I say, that I have put this question to more than one hundred persons, of all ranks in society, of every shade of political opinion, from the keenest radicals to the most uncompromising conservatives. The answer has been uniformly the same; by all, the services of our fellow-member were placed above all comparison; all, moreover, called my attention to the speeches delivered at the meeting at which the

Westminster statue was voted,* as expressing with fidelity the sentiments of the whole English nation. And what are the terms of those speeches?

Lord Liverpool, the Prime Minister of the Crown, calls Watt "one of the most extraordinary persons to whom England has given birth, and one of the greatest benefactors of mankind." He declares, that "his inventions have augmented incalculably the resources of his own country, and even of the whole world." Then, looking at the question in its bearing on politics, "I have known," he says, "in time of war, when the fate of a campaign, and possibly the fate of a war, might depend upon getting a fleet out of port,—contrary winds have prevailed for months, and the whole objects of government have been thereby defeated. Such difficulties can now no longer exist. Let the wind blow from whatever quarter it may, let the destination of our force be to whatever part of the world it may, you have the power and the means, by the Steam Engine, of applying that force at the proper time, and in the proper manner."

"Look round the metropolis," exclaims Sir

* See the Report of the Proceedings at that meeting, given in the Appendix. Besides the speeches quoted by M. Arago, those delivered on the same occasion by Lord Brougham, Lord Hatherton, (then Mr. Littleton), Sir Robert Peel, the Earl of Aberdeen, Mr. Frankland Lewis, Mr. Wedgewood, and Mr. Wilberforce, are not less distinguished for the honourable testimony which they bear to the merits of Mr. Watt, than for their own dignified and touching eloquence. And it is at once interesting and gratifying, to find in the list of eminent persons by whom this great national tribute was so ably supported, the name of the present Mr. Boulton, long the associate and intimate friend of Mr. Watt.—Tr.

Humphry Davy, "our towns, even our villages, our dock-yards, and our manufactories; examine the subterraneous cavities below the surface, and the works above; contemplate our rivers and our canals, and the seas which surround our shores, and every where will be found records of the eternal benefits conferred on us by this great man."

The illustrious President of the Royal Society further moved as a resolution, "That the late James Watt, by the profound science and original genius displayed in his admirable inventions, has, more than any other man of this age, exemplified the practical utility of knowledge, enlarged the power of man over the external world, and both multiplied and diffused the conveniences and enjoyments of human life." Finally, Davy hesitates not to place Watt above Archimedes!

Huskisson, the President of the Board of Trade, abstracting himself for a moment from all considerations of country, proclaims that Mr. Watt's inventions, considered in their relation to the happiness of the whole human race, "stand entitled *to our highest admiration*." He explains how the saving of labour, the power of indefinite multiplication, and the cheapness of manufactures, tend to give a fresh impulse to knowledge, and to diffuse it more widely. "If the steam-engine," he says, "be the most powerful instrument in the hands of man, to alter the face of the physical world, it operates, at the same time, as a powerful moral lever, in forwarding the great cause of civilisation."

In this point of view, Watt appears to him, to

hold a distinguished place among the greatest benefactors of mankind. While, as an Englishman, he says, that "looking back to the demands which were made upon the resources of this country during the late war, perhaps it is not too much to say, at least it is my opinion, that those resources might have failed us before that war was brought to a safe and glorious conclusion, but for the creations of Mr. Watt, by whose discoveries those resources were so greatly multiplied and increased."

The same idea is to be found in the speech of another Member of Parliament, Sir James Mackintosh. Judge whether it is expressed in less strong terms.

"Those vast inventions served, in the first instance, to multiply the resources of our own country, to arm her with new strength, to enable her to sustain more arduous and perilous contests, than any in which she had been before plunged." All things considered, Mackintosh has no hesitation "in affirming, that no man ever had a more evident claim to be honoured by his country, and reverenced by all generations."

Here are some numerical calculations, some arithmetical cyphers, still more eloquent, it strikes me, than the various passages I have just quoted.

The present Mr. Boulton, speaking in 1824, mentions that "a power, equal to that which would require the maintenance of one hundred thousand horses, has been furnished from the single establishment to which Mr. Watt belonged; and, assuming that power to be exercised during three hundred

days in the course of the year, the saving arising from the substitution of steam-power, in lieu of the exertions of the animals themselves, would not be less than three millions of pounds sterling per annum." In England and Scotland, at the same date, the number of engines was above ten thousand. They performed the work of five hundred thousand horses, or from three to four millions of men, with an annual saving of from three to four hundred millions of francs. These results must, at the present time, be more than doubled.

Such is a brief account of what was thought and said of Watt by the Ministers of the Crown, the statesmen, the philosophers, and the manufacturers, who could best appreciate his value. He was the creator of six or eight millions of labourers, of indefatigable and assiduous labourers, among whom the law will never have to suppress either combination or rioting; of labourers working at wages of five centimes per diem; he it was, who, by his brilliant inventions, supplied England with the means of maintaining a deadly struggle, on which her very existence as a nation depended. And what was done to honour, during his life, this new Archimedes, this benefactor of the whole human race, whose memory generations yet unborn will for ever bless?

A Peerage is, in England, the highest of dignities—the greatest of rewards. You naturally conclude that Watt was made a Peer.

It was never even proposed!*

* It was certainly not proposed to make him a Peer, nor would that have suited the fortune, the retired habits, and the unambitious

To speak plainly, so much the worse for that peerage which the name of Watt would have honoured. Well might I be amazed at such an omission, on the part of a nation so justly proud of her great men. On my enquiring the cause of it, what, think you, was the reply? "A dignity such as that of which you speak, is reserved for officers of the army and navy, for influential orators in the House of Commons, and for members of the aristocracy. *It is not the custom*," (I am not inventing,—those were the very words,) "it is not the custom to grant it to scientific or literary men, to artists, or to engineers!" I well knew that in the reign of Queen Anne it was not the custom;—for Newton

character of Mr. Watt. They order these things differently in France, and M. Arago has no doubt supposed that what was almost a matter of course in the one country, should be so also in the other. But the English Government was not altogether unmindful of the merits of Mr. Watt; and it was intimated to him, by a friendly message from Sir Joseph Banks, a few years before his death, that the highest honour usually conferred in England on men of literature and science, was open to him, if he expressed a wish to that effect. He felt flattered by the intimation, but on conversing with his son, it occurred to both, that there were circumstances and considerations which rendered it ineligible. It was, therefore, allowed to drop.

Not long after Mr. Watt's death, it was understood that Lord Liverpool had publicly expressed regret, that a great opportunity of rewarding merit had been lost. That such was the feeling of the King, (George IV.) and of the able men who then formed the ministry, became evident from the eagerness with which they entered into the proposal of erecting a public monument to the memory of Mr. Watt, when suggested by his friends, among whom Mr. Charles Hampden Turner took the lead. The proceedings of the meeting at Freemasons' Hall, which followed, will find an appropriate place in the Appendix to this Eloge.—Tr.

was not made an English peer. But, after a century and a half of progress in science and philosophy; and since each one of us, in the short period of his life, has seen so many wandering kings, deserted, proscribed, supplanted on their thrones by soldiers without genealogy, and sons of their own swords, had I not some right to expect, that men were no longer to be thus circumscribed; that, at least, no one would dare openly to say to them, like the code of the Pharoahs which altereth not, "however great your services, your virtues, and your knowledge may be, not one of you shall clear the limits of his caste;" that, in a word, an absurd custom, (since custom it is), would no longer be suffered to disgrace the institutions of a great nation!

Let us reckon upon the future. A time will come, when the science of destruction shall bend before the arts of peace; when the genius which multiplies our powers, which creates new products, which diffuses comfort and happiness among the great mass of the people, shall occupy, in the general estimation of mankind, that rank which reason and common sense now assign to it.

Then Watt will appear before the grand jury of the inhabitants of the two worlds. Every one will behold him, with the help of his steam-engine, penetrating, in a few weeks, into the bowels of the earth, to depths which, before his time, could not have been reached without an age of the most toilsome labour; excavating vast mines, clearing them, in a few minutes, of the immense volumes

of water which daily inundated them, and extracting from a virgin soil, the inexhaustible mineral treasures which nature has there deposited.

Combining delicacy with power, Watt will twist, with equal success, the huge ropes of the gigantic cable, by which the man-of-war rides at anchor in the midst of the raging ocean, and the microscopic filaments of the aerial gauze and lace, of which fashionable dresses are so principally formed.

A few strokes of the same engine will bring vast swamps into cultivation; and fertile countries will also thus be spared the periodical return of deadly pestilential fevers, caused in those places by the burning heat of the summer sun.

The great mechanical powers which had formerly to be sought for in mountainous districts, at the foot of rapid cascades, will, thanks to Watt's invention, readily and easily arise, in the midst of towns, on any story of a house.

The extent of these powers will vary at the will of the mechanician; it will no longer depend, as heretofore, on the most inconstant of natural causes, —on atmospheric influences.

The different branches of each manufacture may be carried on in one common space, under the same roof; and their products, as they are perfectioned, will diminish in price.

The population, well supplied with food, with clothing, and with fuel, will rapidly increase; it will, by degrees, cover with elegant mansions, every part of the earth; even those which might

justly have been termed the Steppes of Europe, and which the barrenness of ages seemed to condemn to be, for ever, the exclusive domain of wild beasts.

In a few years, hamlets will become great towns; in a few years, boroughs, such as Birmingham, where there could hardly be counted thirty streets, will take their place among the largest, the handsomest, and the richest cities of a mighty kingdom.

Installed in ships, the steam-engine will exercise a power a hundred-fold greater than the triple and quadruple ranks of rowers, of whom our forefathers were wont to exact a labour which is deemed a punishment for the most atrocious criminals.

By the help of a few bushels of coal, man will vanquish the elements; he will play with calms, and contrary winds, and storms.

The passage from one place to another will be much more speedily accomplished; the moment of arrival of the packets may be known beforehand, like that of the public coaches; no one will any longer wander on the shore for whole weeks and months, with a heart tortured with anguish, watching with restless eye the horizon, for the dim outline of the vessel which is to restore a father, a mother, a brother, or a friend.

Lastly, the steam-engine, drawing in its train thousands of travellers, will run on rail-roads with far greater speed than the swiftest race-horse, carrying only his light jockey.

Such is a very brief sketch of the benefits which have been bequeathed to the world by that machine,

of which Papin had, in his works, deposited the germ, and which, after so many ingenious efforts, Watt has brought to an admirable perfection. Those benefits, posterity will never compare with works which have been far too much vaunted, and the real influence of which, at the bar of reason, must remain, for ever, confined to a limited circle of individuals, and a small number of years.

Men formerly spoke of the Augustan Age, and the Age of Louis XIV. Some great men have, ere now, maintained that it would be right to say the Age of Voltaire, of Rousseau, of Montesquieu. For my own part, I have no hesitation in predicting, that, when to the immense services already rendered by the steam-engine, shall be added all the wonders which it yet holds out in prospect, grateful nations will also speak of the Ages of Papin and of Watt.

A biography of Watt which is destined to form a part of our collection of Memoirs, would certainly be incomplete if it did not include a list of the Academic titles which belonged to the illustrious engineer. Besides, this list will occupy but a few lines.

He became a Fellow of the Royal Society of Edinburgh in 1784; of the Royal Society of London in 1785; a Member of the Batavian Society

in 1787 ; and a Correspondent of the Institute in 1808. By a spontaneous and unanimous vote, the Senate of the University of Glasgow conferred on him, in 1806, the honorary degree of Doctor of Laws. In 1814, the Academy of Sciences of the Institute paid him the highest honour which it could bestow ; it nominated him one of its Eight Foreign Associates.

END

OF THE HISTORICAL ELOGE.

APPENDIX.

APPENDIX.

No. I.

HISTORICAL NOTE ON THE DISCOVERY OF THE THEORY OF THE COMPOSITION OF WATER. BY THE RIGHT HON. HENRY LORD BROUGHAM, F.R.S., AND MEMBER OF THE NATIONAL INSTITUTE OF FRANCE.

There can be no doubt whatever, that the experiment of Mr. Warltire, related in Dr. Priestley's 5th volume,* gave rise to this inquiry, at least in

* Mr. Warltire's letter is dated Birmingham, 18th April 1781, and was published by Dr. Priestley in the Appendix to the 2d Vol. of his "Experiments and Observations relating to various branches of Natural Philosophy; with a continuation of the Observations on Air,"—forming, in fact, the 5th volume of his "Experiments and Observations on different kinds of Air;" printed at Birmingham in 1781.

Mr. Warltire's first experiments were made in a copper ball or flask, which held three wine pints, the weight 14 oz.; and his object was to determine "whether heat is heavy or not." After stating his mode of mixing the airs, and of adjusting the balance, he says, he "always accurately balanced the flask of common air, then found the difference of weight after the inflammable air was introduced, that he might be certain he had confined the proper proportion of

England; Mr. Cavendish expressly refers to it, as having set him upon making his experiments.—(Phil. Trans. 1784, p. 126.) The experiment of Mr. Warltire consisted in firing, by electricity, a mixture of inflammable and common air in a close vessel, and two things were said to be observed; *first*, a sensible loss of weight; *second*, a dewy deposit on the sides of the vessel.

Mr. Watt, in a note to p. 332 of his paper, Phil. Trans. 1784, inadvertently states, that the dewy deposit was first observed by Mr. Cavendish; but Mr. Cavendish himself, p. 127, expressly states

each. The electric spark having passed through them, the flask became hot, and was cooled by exposing it to the common air of the room: it was then hung up again to the balance, and a loss of weight was always found, but not constantly the same; upon an average it was two grains."

He goes on to say, "I have fired air in glass vessels, since I saw you (Dr. Priestley) venture to do it, and I have observed, *as you did*, that, though the glass was clean and dry before, yet, after firing the air, it became dewy, and was lined with a sooty substance."

As you are upon a nice balancing of claims, ought not Dr. Priestley to have the credit of first noticing the dew?

In some remarks which follow, by Dr. Priestley, he confirms the loss of weight, and adds, "I do not think, however, that so very bold an opinion, as that of the latent heat of bodies contributing to their weight, should be received without more experiments, and made upon a still larger scale. If it be confirmed, it will no doubt be thought to be a fact of a very remarkable nature, and will do the greatest honour to the sagacity of Mr. Warltire. I must add, that the moment he saw the moisture on the inside of the close glass vessel in which I afterwards fired the inflammable air, he said, that it confirmed an opinion he had long entertained, viz. that common air deposits its moisture when it is phlogisticated."

It seems evident, that neither Mr. Warltire, nor Dr. Priestley, attributed the dew to any thing else than a mechanical deposit of the moisture suspended in common air.—[Note by Mr. James Watt.]

Mr. Warltire to have observed it, and cites Dr. Priestley's 5th volume.

Mr. Cavendish himself could find no loss of weight, and he says, that Dr. Priestley had also tried the experiment, and found none.* But Mr. Cavendish found there was always a dewy deposit, without any sooty matter. The result of many trials was, that common air and inflammable air being burnt together, in the proportion of 1000 measures of the former to 423 of the latter, "about one-fifth of the common air, and nearly all the inflammable air, lose their elasticity, and *are condensed into the dew* which lines the glass." He examined the dew, and found it to be pure water. He therefore concludes, that "almost all the inflammable air, and about one-sixth of the common air, are turned into pure water."

Mr. Cavendish then burned, in the same way, dephlogisticated and inflammable airs, (oxygen and hydrogen gases), and the deposit was always more or less acidulous, accordingly as the air burnt with the inflammable air was more or less phlogisticated. The acid was found to be nitrous. Mr. Cavendish states, that "almost the whole of the inflammable and dephlogisticated air *is converted into pure water.*" And, again, that "if these airs could be obtained perfectly pure, the whole would be condensed." And he accounts for common air and inflammable air, when burnt

* Mr. Cavendish's note, p. 127, would seem to imply this; but I have not found, in any of Dr. Priestley's papers, that he has said so. —[Note by Mr. James Watt.]

together, not producing acid, by supposing that the heat produced is not sufficient. He then says that these experiments, with the exception of what relates to the acid, were made in the summer of 1781, and mentioned to Dr. Priestley; and adds, that "a friend of his, (Mr. Cavendish's), last summer (that is, 1783), gave some account of them to Mr. Lavoisier, as well as of the conclusion drawn from them, that dephlogisticated air is only water deprived of its phlogiston; but, at that time, so far was Mr. Lavoisier from thinking any such opinion warranted, that till he was prevailed upon to repeat the experiment himself, he found some difficulty in believing that nearly the whole of the two airs could be converted into water." The friend is known to have been Dr., afterwards Sir Charles Blagden; and it is a remarkable circumstance, that this passage of Mr. Cavendish's paper appears not to have been in it when originally presented to the Royal Society; for the paper is apparently in Mr. Cavendish's hand, and the paragraph, p. 134, 135, is not found in it, but is added to it, and directed to be inserted in that place. It is, moreover, not in Mr. Cavendish's hand, but in Sir Charles Blagden's; and, indeed, the latter must have given him the information as to Mr. Lavoisier, with whom it is not said that Mr. Cavendish had any correspondence. The paper itself was read 15th January 1784. The volume was published about six months afterwards.

Mr. Lavoisier's memoir (in the Mém. de l'Académie des Sciences for 1781), had been read partly

in November and December 1783, and additions were afterwards made to it. It was published in 1784. It contained Mr. Lavoisier's account of his experiments in June 1783, at which, he says, Sir Charles Blagden was present; and it states that he told Mr. Lavoisier of Mr. Cavendish having "already burnt inflammable air in close vessels, and obtained a very sensible quantity of water." But he, Mr. Lavoisier, says nothing of Sir Charles Blagden having also mentioned Mr. Cavendish's conclusion from the experiment. He expressly states, that the weight of the water was equal to that of the two airs burnt, unless the heat and light which escape are ponderable, which he holds them not to be. His account, therefore, is not reconcilable with Sir Charles Blagden's, and the latter was most probably written as a contradiction of it, after Mr. Cavendish's paper had been read, and when the Mémoires of the Académie were received in this country. These Mémoires were published in 1784, and could not, certainly, have arrived, when Mr. Cavendish's paper was written, nor when it was read to the Royal Society.

But it is further to be remarked, that the passage of Mr. Cavendish's paper in Sir Charles Blagden's handwriting, only mentions the experiments having been communicated to Dr. Priestley; they were made, says the passage, in 1781, and communicated to Dr. Priestley; it is not said when, nor is it said that "the conclusions drawn from them," and which Sir Charles Blagden says he communicated to Mr. Lavoisier in summer 1783, were ever com-

municated to Dr. Priestley; and Dr. Priestley, in his paper, (referred to in Mr. Cavendish's), which was read June 1783, and written before April of that year, says nothing of Mr. Cavendish's theory, though he mentions his experiment.

Several propositions then are proved by this statement.

First, That Mr. Cavendish, in his paper, read 15th January 1784, relates the capital experiment of burning oxygen and hydrogen gases in a close vessel, and finding pure water to be the produce of the combustion.

Secondly, That, in the same paper, he drew from this experiment the conclusion, that the two gases were converted or turned into water.

Thirdly, That Sir Charles Blagden inserted in the same paper, with Mr. Cavendish's consent, a statement that the experiment had first been made by Mr. Cavendish in summer 1781, and mentioned to Dr. Priestley, though it is not said when, nor is it said that any conclusion was mentioned to Dr. Priestley, nor is it said at what time Mr. Cavendish first drew that conclusion. *A most material omission.*

Fourthly, That in the addition made to the paper by Sir Charles Blagden, the conclusion of Mr. Cavendish is stated to be, that oxygen gas is water deprived of phlogiston; this addition having been made after Mr. Lavoisier's memoir arrived in England.

It may further be observed, that in another addition to the paper, which is in Mr. Cavendish's

handwriting, and which was certainly made after Mr. Lavoisier's memoir had arrived, Mr. Cavendish for the first time distinctly states, as upon Mr. Lavoisier's hypothesis, that water consists of hydrogen united to oxygen gas. There is no substantial difference, perhaps, between this and the conclusion stated to have been drawn by Mr. Cavendish himself, that oxygen gas is water deprived of phlogiston, supposing phlogiston to be synonymous with hydrogen ; but the former proposition is certainly the more distinct and unequivocal of the two : and it is to be observed that Mr. Cavendish, in the original part of the paper, *i. e.* the part read January 1784, before the arrival of Lavoisier's, considers it more just to hold inflammable air to be phlogisticated water than pure phlogiston, (p. 140.)

We are now to see what Mr. Watt did ; and the dates here become very material. It appears, that he wrote a letter to Dr. Priestley on 26th April 1783, in which he reasons on the experiment of burning the two gases in a close vessel, and draws the conclusion, "that water is composed of dephlogisticated air and phlogiston, deprived of part of their latent heat."* The letter was received

* It may with certainty be concluded from Mr. Watt's private and unpublished letters, of which the copies taken by his copying-machine, then recently invented, are preserved, that his theory of the composition of water was already formed in December 1782, and probably much earlier. Dr. Priestley, in his paper of 21st April 1783, p. 416, states, that Mr. Watt, prior to his (the Doctor's) experiments, had entertained the idea of the possibility of the conversion of water or steam into permanent air. And Mr. Watt himself, in his paper, Phil. Trans. p. 335, asserts, that for many years he had

by Dr. Priestley and delivered to Sir Joseph Banks, with a request that it might be read to the Royal Society; but Mr. Watt afterwards desired this to be delayed, in order that he might examine some new experiments of Dr. Priestley, so that it was not read until the 22d April 1784. In the interval between the delivery of this letter to Dr. Priestley, and the reading of it, Mr. Watt had addressed another letter to Mr. De Luc, dated 26th November 1783,* with many further observations and

entertained the opinion that air was a modification of water, and he enters at some length into the facts and reasoning upon which that deduction was founded.—[Note by Mr. James Watt.]

* The letter was addressed to Mr. J. A. De Luc, the well-known Genevese philosopher, then a Fellow of the Royal Society, and Reader to Queen Charlotte. He was the friend of Mr. Watt, who did not then belong to the Society. Mr. De Luc, following the motions of the Court, was not always in London, and seldom attended the meetings of the Royal Society. He was not present when Mr. Cavendish's paper of 15th January 1784, was read; but, hearing of it from Dr. Blagden, he obtained a loan of it from Mr. Cavendish, and writes to Mr. Watt on the 1st March following, to apprise him of it, adding that he has perused it, and promising an analysis. In the postscript, he states, "In short, they expound and prove your system, word for word, and say nothing of you." The promised analysis is given in another letter of the 4th of the same month. Mr. Watt replies on the 6th, with all the feelings which a conviction he had been ill-treated was calculated to inspire, and makes use of those vivid expressions which M. Arago has quoted; he states his intention of being in London in the ensuing week, and his opinion, that the reading of his letter to the Royal Society will be the proper step to be taken. He accordingly went there, waited upon the President of the Royal Society, Sir Joseph Banks, was received with all the courtesy and just feeling which distinguished that most honourable man; and it was settled that both the letter to Dr. Priestley of 26th April 1783, and that to Mr. De Luc of 26th November 1783, should be successively read. The former was done on the 22d, and the latter on the 29th April 1784.—[Note by Mr. James Watt.]

reasonings, but almost the whole of the original letter is preserved in this, and is distinguished by inverted commas. One of the passages thus marked, is that which has the important conclusion above mentioned; and that letter is stated, in the subsequent one, to have been communicated to several members of the Royal Society at the time of its reaching Dr. Priestley, viz. April 1783.

In Mr. Cavendish's paper as at first read, no allusion is to be found to Mr. Watt's theory. But in an addition made in Mr. Cavendish's own hand, after Mr. Watt's paper had been read, there is a reference to that theory, (Phil. Trans. 1784, p. 140), and Mr. Cavendish's reasons are given for not encumbering his theory with that part of Mr. Watt's which regards the evolution of latent heat. It is thus left somewhat doubtful, whether Mr. Cavendish had ever seen the letter of April 1783, or whether he had seen only the paper (of 26th November 1783) of which that letter formed a part, and which was read 29th April 1784. That the first letter was for some time (two months, as appears from the papers of Mr. Watt), in the hands of Sir Joseph Banks, and other members of the Society, during the preceding spring, is certain, from the statements in the note to p. 330; and that Sir Charles Blagden, the Secretary, should not have seen it, seems impossible; for Sir Joseph Banks must have delivered it to him at the time when it was intended to be read at one of the Society's meetings, (Phil. Trans. p. 330, Note), and, as the letter itself remains among the Society's Records,

in the same volume with the paper into which the greater part of it was introduced, it must have been in the custody of Sir C. Blagden. It is equally difficult to suppose, that the person who wrote the remarkable passage already referred to, respecting Mr. Cavendish's conclusions having been communicated to Mr. Lavoisier in the summer of 1783, (that is, in June), should not have mentioned to Mr. Cavendish that Mr. Watt had drawn the same conclusion in the spring of 1783, (that is, in April at the latest). For the conclusions are identical, with the single difference, that Mr. Cavendish calls dephlogisticated air, water deprived of its phlogiston, and Mr. Watt says, that water is composed of dephlogisticated air and phlogiston.

We may remark, there is the same uncertainty or vagueness introduced into Mr. Watt's theory, which we before observed in Mr. Cavendish's, by the use of the term Phlogiston, without exactly defining it.* Mr. Cavendish leaves it uncertain, whether or not he meant by phlogiston simply inflammable air, and he inclines rather to call inflammable air, water united to phlogiston. Mr. Watt says expressly, even in his later paper, (of November 1783), and in a passage not to be found in the

* Mr. Watt, in a note to his paper of 26th November 1783, p. 331, observes, "previous to Dr. Priestley's making these experiments, Mr. Kirwan had proved, by very ingenious deductions from other facts, that inflammable air was, in all probability, the real phlogiston in an aërial form. These arguments were perfectly convincing to me, but it seems proper to rest that part of the argument on direct experiment."—[Note by Mr. James Watt.]

letter of April 1783, that he thinks that inflammable air contains a small quantity of water, and much elementary heat. It must be admitted that such expressions as these on the part of both of those great men, betoken a certain hesitation respecting the theory of the composition of water. If they had ever formed to themselves the idea, that water is a compound of the two gases deprived of their latent heat,—that is, of the two gases,—with the same distinctiveness which marks Mr. Lavoisier's statement of the theory, such obscurity and uncertainty would have been avoided.*

* Mr. Watt, in his letter of 26th April 1783, thus expresses his theory and conclusions, (Phil. Trans. p. 333):—"Let us now consider what obviously happens in the case of the deflagration of the inflammable and dephlogisticated air. These two kinds of air unite with violence, they become red hot, and, upon cooling, totally disappear. When the vessel is cooled, a quantity of water is found in it, equal to the weight of the air employed. This water is then the only remaining product of the process, and *water*, *light*, and *heat*, are all the products," (unless, he adds in the paper of November, there be some other matter set free, which escapes our senses). "*Are we not then authorised to conclude, that water is composed of dephlogisticated air and phlogiston, deprived of their latent or elementary heat; that dephlogisticated or pure air is composed of water deprived of its phlogiston, and united to elementary heat and light; that the latter are contained in it in a latent state, so as not to be sensible to the thermometer or to the eye; and if light be only a modification of heat, or a circumstance attending it, or a component part of the inflammable air, then pure or dephlogisticated air is composed of water deprived of its phlogiston, and united to elementary heat?*"

Is not this as clear, precise, and intelligible, as the conclusions of Mr. Lavoisier?—[Note by Mr. James Watt.]

The obscurity with which Lord Brougham charges the theoretical conceptions of Watt and Cavendish, does not appear to me well-founded. In 1784, the preparation of two permanent and very dissimilar gases was known. Some called these gases, pure air and inflammable air; others, dephlogisticated air and phlogiston; and

Several further propositions may now be stated, as the result of the facts regarding Mr. Watt.

First, That there is no evidence of any person having reduced the theory of composition to writing, in a shape which now remains, so early as Mr. Watt.

Secondly, That he states the theory, both in April and November 1783, in language somewhat

lastly, others, oxygen and hydrogen. By combining dephlogisticated air and phlogiston, water was produced equal in weight to that of the two gases. Water thenceforward was no longer a simple body, but a compound of dephlogisticated air and of phlogiston. The chemist who drew that conclusion, might have erroneous ideas as to the intimate nature of phlogiston, without that throwing any uncertainty upon the merit of his first discovery. Even at this day, have we *mathematically demonstrated* that hydrogen (or phlogiston) is an elementary body; or that it is not, as Watt and Cavendish supposed at the time, the combination of a radical and of a little water?—[Note by M. Arago.]

It should be borne in mind that the new chemical nomenclature was not proposed to the Academy of Sciences by the Messrs. de Morveau, Lavoisier, Berthollet, and de Fourcroy, until 1787, accompanied by introductory memoirs by M. Lavoisier, and M. de Morveau.

Lavoisier himself had suggested the use of the term *acidifying principle*, or *oxygen*, in 1778, for the basis of pure or dephlogisticated air; and he used it in subsequent memoirs in 1780 and 1782; but it was not until the decomposition of water was discovered in 1783 and 1784, that he fully adopted it. Berthollet, perhaps the most philosophical chemist of France, did not become a convert to this nomenclature until 1785, nor did de Morveau and Fourcroy, according to the statement of the latter, fully enter into it until the end of 1786. As far as we recollect, it was first legitimated, if we may use the expression, in Lavoisier's System of Chemistry in 1789. It is surely, then, wrong to expect that Mr. Watt, in expounding his theory in 1783, should use a phraseology not generally sanctioned in France until four years later, not admitted by Black, Priestley, Kirwan, and other great English chemists, until a still more recent period, and by some of them never recognised at all.—[Note by Mr. James Watt.]

more distinctly referring to composition, than Mr. Cavendish does in 1784, and that his reference to the evolution of latent heat renders it more distinct than Mr. Cavendish's.

Thirdly, That there is no proof, nor even any assertion, of Mr. Cavendish's theory (what Sir C. Blagden calls his conclusion,) having been communicated to Dr. Priestley before Mr. Watt stated his theory in 1783, still less of Mr. Watt having heard of it, while his whole letter shews that he never had been aware of it, either from Dr. Priestley, or from any other quarter.

Fourthly, That Mr. Watt's theory was well known among the members of the Society, some months before Mr. Cavendish's statement appears to have been reduced into writing, and eight months before it was presented to the Society. We may, indeed, go farther, and affirm, as another deduction from the facts and dates, that, as far as the evidence goes, there is proof of Mr. Watt having first drawn the conclusion, at least that no proof exists of any one having drawn it so early as he is proved to have done.

Lastly, That a reluctance to give up the doctrine of phlogiston, a kind of timidity on the score of that long-established and deeply-rooted opinion, prevented both Mr. Watt and Mr. Cavendish from doing full justice to their own theory; while Mr. Lavoisier, who had entirely shaken off these trammels, first presented the new doctrine in its entire perfection and consistency.*

* It could scarcely be expected that Mr. Watt, writing and publishing for the first time, amid the distractions of a large manufac-

All three may have made the important step nearly at the same time, and unknown to each other; the step, namely, of concluding from the experiment, that the two gases entered into combination, and that water was the result; for this, with more or less of distinctness, is the inference which all three drew.

But there is the statement of Sir Charles Blagden, to shew that Mr. Lavoisier had heard of Mr. Cavendish's drawing this inference before his (Mr. Lavoisier's) capital experiment was made;* and it appears that Mr. Lavoisier, after Sir C. Blagden's statement had been embodied in Mr. Cavendish's paper and made public, never gave any contradiction to it in any of his subsequent memoirs which are to be found in the Mémoires de l'Académie, though his own account of that experiment, and of what then passed, is inconsistent with Sir Charles Blagden's statement.†

But there is not any assertion at all, even from

turing concern, and of extensive commercial affairs, could compete with the eloquent and practised pen of so great a writer as Lavoisier; but it seems to me, who am certainly no impartial judge, that the summing-up of his theory, (p. 333 of his paper,) here quoted p. 167, is equally luminous and well expressed as are the conclusions of the illustrious French chemist.—[Note by Mr. James Watt.]

* In the letter which Sir Charles Blagden addressed to Professor Crell, and which appeared in Crell's *Annalen* for 1786, professing to give a detailed history of the discovery, he says expressly, that he had communicated to Lavoisier the conclusions both of Cavendish *and Watt*. This last name appears in that letter for the first time in the recital of the verbal communications of the Secretary of the Royal Society, and is never mentioned by Lavoisier.—[Note by Mr. James Watt.]

† Could Blagden's letter to Crell also have escaped Lavoisier's notice?—[Note by Mr. James Watt.]

Sir C. Blagden, zealous for Mr. Cavendish's priority as he was, that Mr. Watt had ever heard of Mr. Cavendish's theory before he formed his own.

Whether or not Mr. Cavendish had heard of Mr. Watt's theory previous to drawing his conclusions, appears more doubtful. The supposition that he had so heard, rests on the improbability of his (Sir Charles Blagden's,) and many others knowing what Mr. Watt had done, and not communicating it to Mr. Cavendish, and on the omission of any assertion in Mr. Cavendish's paper, even in the part written by Sir C. Blagden with the view of claiming priority as against Mr. Lavoisier, that Mr. Cavendish had drawn his conclusion before April 1783, although in one of the additions to that paper reference is made to Mr. Watt's theory.

As great obscurity hangs over the material question at what time Mr. Cavendish first drew the conclusion from his experiment, it may be as well to examine what that great man's habit was in communicating his discoveries to the Royal Society.

A Committee of the Royal Society, with Mr. Gilpin the clerk, made a series of experiments on the formation of nitrous acid, under Mr. Cavendish's direction, and to satisfy those who had doubted his theory of its composition, first given accidentally in the paper of January 1784, and afterwards more fully in another paper, June 1785. Those experiments occupied from the 6th Decem-

ber 1787, to 19th March 1788, and Mr. Cavendish's paper upon them was read 17th April 1788. It was, therefore, written and printed within a month of the experiments being concluded.

Mr. Kirwan answered Mr. Cavendish's paper (of 15th January 1784,) on water, in one which was read 5th February 1784, and Mr. Cavendish replied in a paper read 4th March 1784.

Mr. Cavendish's experiments on the density of the earth, were made from the 5th August 1797, to the 27th May 1798. The paper upon that subject was read 27th June 1798.

The account of the eudiometer was communicated at apparently a greater interval; at least the only time mentioned in the account of the experiments is the latter half of 1781, and the paper was read January 1783. It is, however, probable from the nature of the subject, that he made further trials during the year 1782.

That Mr. Watt formed his theory during the few months or weeks immediately preceding April 1783, seems probable.* It is certain that he considered the theory as his own, and makes no reference to any previous communication from any one upon the subject, nor of having ever heard of Mr. Cavendish drawing the same conclusion.

The improbability must also be admitted to be extreme, of Sir Charles Blagden ever having heard

* That the idea existed in his mind previously, is proved by his declarations to Dr. Priestley, cited by the latter; by his own assertions, p. 335 of his paper; and by the existing copies of his letters in December 1782.—[Note by Mr. James Watt.]

of Mr. Cavendish's theory prior to the date of Mr. Watt's letter, and not mentioning that circumstance in the insertion which he made in Mr. Cavendish's paper.

It deserves to be farther mentioned, that Mr. Watt left the correction of the press, and every thing relating to the publishing of his paper, to Sir Charles Blagden. A letter remains from him, to that effect, written to Sir Charles Blagden, and Mr. Watt never saw the paper until it was printed.*

* The notes of Mr. James Watt formed part of the manuscript transmitted to me by Lord Brougham; and it is at the express desire of my illustrious fellow-member, that I have printed them, as a useful commentary upon his essay.—[Note by M. Arago.]

No. II.

CHARACTER OF MR. WATT;

BY

THE HON. FRANCIS JEFFREY, LORD JEFFREY.*

Mr. James Watt, the great improver of the steam-engine, died on the 25th of August, 1819, at his seat of Heathfield, near Birmingham, in the 84th year of his age.

This name fortunately needs no commemoration of ours; for he that bore it survived to see it crowned with undisputed and unenvied honours; and many generations will probably pass away, before it shall have gathered "all its fame." We have said that Mr. Watt was the great *improver* of the steam-engine; but, in truth, as to all that is admirable in its structure, or vast in its utility, he should rather be described as its *inventor*. It was by his inventions that its action was so regulated, as to make it capable of being applied to the finest and most delicate manufactures, and its power so increased, as to set weight and solidity at defiance. By his admirable contrivance, it has become a thing stupendous alike for its force and its flexibility,—for the prodigious power which it can exert, and the ease, and precision, and ductility, with which it can be varied, distributed, and applied.

* First published in an Edinburgh newspaper, (the Scotsman,) of the 4th September 1819.

The trunk of an elephant, that can pick up a pin or rend an oak, is as nothing to it. It can engrave a seal, and crush masses of obdurate metal before it—draw out, without breaking, a thread as fine as gossamer, and lift a ship of war like a bauble in the air. It can embroider muslin and forge anchors, —cut steel into ribbands, and impel loaded vessels against the fury of the winds and waves.

It would be difficult to estimate the value of the benefits which these inventions have conferred upon this country. There is no branch of industry that has not been indebted to them; and, in all the most material, they have not only widened most magnificently the field of its exertions, but multiplied a thousand-fold the amount of its productions. It is our improved steam-engine that has fought the battles of Europe, and exalted and sustained, through the late tremendous contest, the political greatness of our land. It is the same great power which now enables us to pay the interest of our debt, and to maintain the arduous struggle in which we are still engaged, [1819], with the skill and capital of countries less oppressed with taxation. But these are poor and narrow views of its importance. It has increased indefinitely the mass of human comforts and enjoyments, and rendered cheap and accessible, all over the world, the materials of wealth and prosperity. It has armed the feeble hand of man, in short, with a power to which no limits can be assigned; completed the dominion of mind over the most refractory qualities of matter; and laid a sure foundation for all those future miracles of mechanic power which are to

aid and reward the labours of after generations. It is to the genius of one man, too, that all this is mainly owing; and certainly no man ever bestowed such a gift on his kind. The blessing is not only universal, but unbounded; and the fabled inventors of the plough and the loom, who were deified by the erring gratitude of their rude cotemporaries, conferred less important benefits on mankind than the inventor of our present steam-engine.

This will be the fame of Watt with future generations; and it is sufficient for his race and his country. But to those to whom he more immediately belonged, who lived in his society and enjoyed his conversation, it is not, perhaps, the character in which he will be most frequently recalled —most deeply lamented—or even most highly admired. Independently of his great attainments in mechanics, Mr. Watt was an extraordinary, and in many respects a wonderful man. Perhaps no individual in his age possessed so much and such varied and exact information,—had read so much, or remembered what he had read so accurately and well. He had infinite quickness of apprehension, a prodigious memory, and a certain rectifying and methodising power of understanding, which extracted something precious out of all that was presented to it. His stores of miscellaneous knowledge were immense,—and yet less astonishing than the command he had at all times over them. It seemed as if every subject that was casually started in conversation with him, had been that which he had been last occupied in studying and exhausting;

—such was the copiousness, the precision, and the admirable clearness of the information which he poured out upon it without effort or hesitation. Nor was this promptitude and compass of knowledge confined in any degree to the studies connected with his ordinary pursuits. That he should have been minutely and extensively skilled in chemistry and the arts, and in most of the branches of physical science, might perhaps have been conjectured; but it could not have been inferred from his usual occupations, and probably is not generally known, that he was curiously learned in many branches of antiquity, metaphysics, medicine, and etymology, and perfectly at home in all the details of architecture, music, and law. He was well acquainted, too, with most of the modern languages—and familiar with their most recent literature. Nor was it at all extraordinary to hear the great mechanician and engineer detailing and expounding, for hours together, the metaphysical theories of the German logicians, or criticising the measures or the matter of the German poetry.

His astonishing memory was aided, no doubt, in a great measure, by a still higher and rarer faculty—by his power of digesting and arranging in its proper place all the information he received, and of casting aside and rejecting, as it were instinctively, whatever was worthless or immaterial. Every conception that was suggested to his mind seemed instantly to take its place among its other rich furniture, and to be condensed into the smallest and most convenient form. He never appeared,

therefore, to be at all encumbered or perplexed with the *verbiage* of the dull books he perused, or the idle talk to which he listened; but to have at once extracted, by a kind of intellectual alchemy, all that was worthy of attention, and to have reduced it, for his own use, to its true value and to its simplest form. And thus it often happened, that a great deal more was learned from his brief and vigorous account of the theories and arguments of tedious writers, than an ordinary student could ever have derived from the most painful study of the originals,—and that errors and absurdities became manifest from the mere clearness and plainness of his statement of them, which might have deluded and perplexed most of his hearers without that invaluable assistance.

It is needless to say, that, with those vast resources, his conversation was at all times rich and instructive in no ordinary degree: but it was, if possible, still more pleasing than wise, and had all the charms of familiarity, with all the substantial treasures of knowledge. No man could be more social in his spirit, less assuming or fastidious in his manners, or more kind and indulgent towards all who approached him. He rather liked to talk,—at least in his latter years; but though he took a considerable share of the conversation, he rarely suggested the topics on which it was to turn, but readily and quietly took up whatever was presented by those around him, and astonished the idle and barren propounders of an ordinary theme, by the treasures which he drew from the mine they had

unconsciously opened. He generally seemed, indeed, to have no choice or predilection for one subject of discourse rather than another; but allowed his mind, like a great cyclopædia, to be opened at any letter his associates might choose to turn up, and only endeavoured to select, from his inexhaustible stores, what might be best adapted to the taste of his present hearers. As to their capacity he gave himself no trouble; and, indeed, such was his singular talent for making all things plain, clear, and intelligible, that scarcely any one could be aware of such a deficiency in his presence. His talk, too, though overflowing with information, had no resemblance to lecturing or solemn discoursing, but, on the contrary, was full of colloquial spirit and pleasantry. He had a certain quiet and grave humour, which ran through most of his conversation, and a vein of temperate jocularity, which gave infinite zest and effect to the condensed and inexhaustible information, which formed its main staple and characteristic. There was a little air of affected testiness, and a tone of pretended rebuke and contradiction, with which he used to address his younger friends, that was always felt by them as an endearing mark of his kindness and familiarity,—and prized accordingly, far beyond all the solemn compliments that ever proceeded from the lips of authority. His voice was deep and powerful,—though he commonly spoke in a low and somewhat monotonous tone, which harmonized admirably with the weight and brevity of his observations, and set off to the greatest advantage the pleasant

anecdotes, which he delivered with the same grave brow, and the same calm smile playing soberly on his lips. There was nothing of effort indeed, or impatience, any more than of pride or levity, in his demeanour; and there was a finer expression of reposing strength, and mild self-possession in his manner, than we ever recollect to have met with in any other person. He had in his character the utmost abhorrence for all sorts of forwardness, parade, and pretensions; and, indeed, never failed to put all such impostures out of countenance, by the manly plainness and honest intrepidity of his language and deportment.

In his temper and dispositions he was not only kind and affectionate, but generous, and considerate of the feelings of all around him; and gave the most liberal assistance and encouragement to all young persons who showed any indications of talent, or applied to him for patronage or advice. His health, which was delicate from his youth upwards, seemed to become firmer as he advanced in years; and he preserved, up almost to the last moment of his existence, not only the full command of his extraordinary intellect, but all the alacrity of spirit, and the social gaiety which had illumined his happiest days. His friends in this part of the country never saw him more full of intellectual vigour and colloquial animation,—never more delightful or more instructive,—than in his last visit to Scotland in autumn 1817. Indeed, it was after that time that he applied himself, with all the ardour of early life, to the invention of a

machine for mechanically copying all sorts of sculpture and statuary;—and distributed among his friends some of its earliest performances, as the productions of a young artist just entering on his eighty-third year.

This happy and useful life came, at last, to a gentle close. He had suffered some inconvenience through the summer; but was not seriously indisposed till within a few weeks from his death. He then became perfectly aware of the event which was approaching; and, with his usual tranquillity and benevolence of nature, seemed only anxious to point out to the friends around him, the many sources of consolation which were afforded by the circumstances under which it was about to take place. He expressed his sincere gratitude to Providence for the length of days with which he had been blessed, and his exemption from most of the infirmities of age; as well as for the calm and cheerful evening of life that he had been permitted to enjoy, after the honourable labours of the day had been concluded. And thus, full of years and honours, in all calmness and tranquillity, he yielded up his soul, without pang or struggle,—and passed from the bosom of his family to that of his God.

No. III.

PROCEEDINGS OF THE PUBLIC MEETING HELD AT FREEMASONS' HALL, ON THE 18TH JUNE, 1824, FOR ERECTING A MONUMENT TO THE LATE JAMES WATT.*

INTRODUCTION.

MANY of the friends and admirers of the late Mr. Watt had long regretted, that no tribute of national gratitude had been paid to a man, whose inventions had so essentially promoted the prosperity and increased the resources of the British empire; and whose talents and discoveries as a philosopher were universally allowed, both at home and abroad, to have conferred honour upon his country.

Those feelings were strengthened by the recent exhibition of his statue by Chantrey; not more admirable as an exquisite work of art, than as a striking and characteristic resemblance; and by the appearance, nearly at the same time, of an interesting, though brief memoir of his life, in the last volume of the Encyclopædia Britannica, to which the beautiful delineation of his character by Mr. Jeffrey was subjoined. Time and reflection

* London, John Murray, Albemarle-Street, 1824.

had contributed to enhance their estimate of Mr. Watt's extraordinary merits, while the beneficial effects of his inventions were every day becoming more and more conspicuous in all parts of the civilized world. It was known that the statue was intended by the present Mr. Watt to be placed over his father's remains in the parish church of Handsworth, in Staffordshire; and that another statue, for which that gentleman had engaged the same great artist, was designed by him to be presented to the university and city of Glasgow, as a mark of respect to the place where his father's talents had been first encouraged, and where his great improvement in the principle of the Steam Engine had been made. But the friends of Mr. Watt were decidedly of opinion, that it should not be left to filial piety alone, to commemorate genius and talents from which the whole community had derived such signal benefits; and they, in consequence, formed the resolution of erecting an appropriate memorial in the metropolis of the British empire, by private subscription among themselves. They could not, however, divest themselves of the conviction, that Mr. Watt had peculiar and indubitable claims to the highest honours that are ever conferred by government, on men who have deserved well of their country; and under this persuasion, they considered it right to make application to his Majesty's ministers, to sanction a vote of Parliament for the erection of a suitable monument, either in Westminster Abbey, or in St. Paul's Cathedral.

To this application, a prompt and willing attention was given by the leading members of administration. It appeared to accord with their own wishes and opinions; and expectations were for some time entertained of its being carried into effect. But no precedent could be discovered for such a measure; and ministers felt great difficulty in establishing one, which might eventually place them under the painful and invidious necessity of discussing the merits of other eminent men, for whom claims might be brought forward. In intimating this difficulty, they at the same time announced the high sense which His Majesty entertained of the merits and public services of Mr. Watt, and his gracious desire to contribute a large sum towards the erection of a monument by public subscription. Ministers likewise expressed their individual wishes to take a prominent part in the execution of such a plan; which, supported, as they were convinced it would be, by the general concurrence of the country, would become a national tribute to Mr. Watt's merits, and a permanent record of the public gratitude.

To a proposal so honourable to the memory of Mr. Watt, his friends gave a ready and cordial assent; and, as the session of Parliament was drawing to a close, and many of its Members most friendly to the measure were leaving town, it was resolved to call a public meeting in London, to be held as speedily as circumstances would admit. A notice was accordingly inserted in the newspapers, and addressed, by circular, to those gentle-

men who were presumed likely to take an interest in the proceedings. The unavoidable shortness of time prevented the attendance of many warm friends of Mr. Watt from distant parts of the kingdom,—yet it may truly be said, that a meeting more distinguished by rank, station, and talent, was never before assembled to do honour to genius, and to modest and retiring worth; and that a more spontaneous, noble, and discriminating testimony was never borne to the virtues, talents, and public services of any individual, in any age or country.

To present an authentic record of the proceedings of that meeting is the object of the following pages;—proceedings as honourable to the Monarch who patronized, as to the eminent statesmen and distinguished men who bore a part in them; and which must ever prove a source of pride and gratification to the friends of Mr. Watt.

C. H. TURNER,
Chairman of the Committee.

Rook's Nest,
Godstone, Nov. 1, 1824.

MONUMENT TO MR. WATT.

A public meeting will be held at the Freemasons' Tavern, on Friday next, the 18th instant, at one o'clock, to consider of the propriety of erecting a monument to the late James Watt; as a

tribute of national gratitude to him, who, by his genius and science, has multiplied the resources of his country, and improved the condition of all mankind.

The Earl of Liverpool, K.G., in the Chair.

June 12, 1824.

PROCEEDINGS AT THE FREEMASONS' TAVERN.

Earl of Liverpool.—Gentlemen, we are assembled here for the purpose of paying a public tribute of respect and gratitude, to the memory of one of the most extraordinary persons to whom our country has given birth. It will not be denied that, amongst the benefactors of mankind, there are few who can have a greater claim to public gratitude, than those who have improved the *productive powers of human industry;* and where shall we find, in modern times, or, I may say, in any age of the world, such an invention as the Steam Engine? Of that invention, the late Mr. Watt, by his improvements, may be said to have been almost the author. It was by his steady perseverance, by the sagacity of his mind, by his patient thinking, that he was enabled to apply the profoundest principles of science to the practical purposes of life; and, by abridging human and animal labour, and increasing the force of mechanical power, to augment incalculably the resources of his own country, and even of the whole world.

Gentlemen:—in such an assembly as the present, where there must be so many much better qualified to descant upon such a subject than I am, it would be presumptuous in me to say much of the merits of the invention of which Mr. Watt was the author. I cannot avoid, however, saying a little upon it. It has been compared to the trunk of the elephant, and the comparison is so far just, that there is nothing so small, and nothing so great, that it will not reach. It has improved the texture of the most refined manufactures, whilst, at the same time, half of the difficulties of navigation have vanished before it. Gentlemen:—we have now no delay in our communications with any part of the world. Whatever it may be necessary to communicate, and to whatever quarter, be the winds friendly or be they contrary, the power of the Steam Engine overcomes all difficulties. Gentlemen:—I have known in time of war, when the fate of a campaign, and possibly the fate of a war, might depend upon getting a fleet out of port,—contrary winds have prevailed for months, and the whole objects of government have been thereby defeated. Such difficulties can now no longer exist. Let the wind blow from whatever quarter it may,—let the destination of our force be to whatever part of the world it may, you have the power and the means, by the Steam Engine, of applying that force at the proper time and in the proper manner.

I will not detain you longer upon the merits of this invention; but I must say a few words upon

the respected author of it, who is the immediate subject of our assembling this day, and with whom I have the satisfaction of saying I had the honour of having some personal acquaintance. Gentlemen:—a more excellent and amiable man, in all the relations of life, I believe never existed. If he did not meet with all the personal consideration to which his great talents and great services may appear to have entitled him, I am satisfied it was owing to the simplicity of his character, to the modesty of his nature, to the absence in him of every thing like presumption and ostentation; and to the unwillingness to obtrude himself, not only upon the great and powerful, but even on those branches of the scientific world to which he more immediately belonged. Gentlemen:—it is a satisfaction to me to be able to say so much from my own knowledge of the personal merits of Mr. Watt. His discoveries are known to the world; and I trust we live in an age too liberal not to feel that if those discoveries and that science are advantageous to mankind in general, this circumstance, so far from diminishing his merit in our eyes, must greatly increase it; but, at the same time, we need not be ashamed to say, that if the whole world does experience and is likely to experience the benefits of the discoveries of Mr. Watt, they are particularly advantageous to the country which gave him birth. We can never doubt, that by our wealth, by our capital, by the means which Providence has afforded us in being the country which has, of the whole world, the greatest com-

mand of fuel, we must always have advantages in the employment of the Steam Engine, which can belong to no other nation in an equal degree with ourselves. When, therefore, we hear stated the different effects it may have upon the operations of future war, we may be persuaded that whatever additional discovery, grounded on the Steam Engine, may be made elsewhere, whatever temporary advantages may be acquired by other powers, even if such should occur, we may rest assured that the permanent advantages of this great invention will be felt principally in England.

Gentlemen:—I will detain you no longer; but I cannot close without informing you, that I am commanded by the King, to say that he is most deeply sensible of the merits of the individual whose services you are called upon this day to recognise, and that he is most anxious that there should not be any subscription in testimony of services like those of Mr. Watt, in which his name should not appear. His Majesty has authorised me to put down five hundred pounds in his name.

Sir Humphry Davy.—I ought to apologise for rising so immediately to address this meeting, but as the distinguished person whose memory we have met together to honour, owes his claims to the gratitude of society to his scientific labours, and as he was one of the most illustrious Fellows of that institution for the promotion of natural knowledge over which I have the honour to preside, I consider it as a duty incumbent on me to endeavour to set forth his peculiar and exalted

merits, which live in the recollection of his contemporaries, and will transmit his name with immortal glory to posterity. Those who consider James Watt only as a great practical mechanic, form a very erroneous idea of his character:—He was equally distinguished as a natural philosopher and a chemist, and his inventions demonstrate his profound knowledge of those sciences, and that peculiar characteristic of genius, the union of them for practical application. The Steam Engine, before his time, was a rude machine, the result of simple experiments on the compression of the atmosphere, and the condensation of steam. Mr. Watt's improvements were not produced by accidental circumstances, or by a single ingenious thought; they were founded on delicate and refined experiments, connected with the discoveries of Dr. Black. He had to investigate the cause of the cold produced by evaporation, of the heat occasioned by the condensation of steam;—to determine the source of the air appearing when water was acted upon by an exhausting power; the ratio of the volume of steam to its generating water, and the law by which the elasticity of steam increased with the temperature;—labour, time, numerous and difficult experiments, were required for the ultimate result; and, when his principle was obtained, the application of it to produce the movement of machinery demanded a new species of intellectual and experimental labour. He engaged in this with all the ardour which success inspires, and was obliged to bring all the mechani-

eal powers into play, and all the resources of his own fertile mind into exertion; he had to convert rectilineal into rotatory motion, and to invent parallel motion. After years of intense labour, he obtained what he wished for; and at last, by the regulating centrifugal force of the *governor*, placed the machine entirely under the power of the mechanic, and gave perfection to a series of combinations, unrivalled for the genius and sagacity displayed in their invention, and for the new power they have given to civilised man. Upon the nature of this power, I can hardly venture to speak; so extensive and magnificent a subject demands a more accomplished and able orator. What is written on the monument of another illustrious and kindred philosopher, in relation to one great work, and a single spot, will apply to Watt in almost every part of the empire:—

"Si monumentum requiris circumspice."

And where can we cast our eyes, without seeing results dependent upon or connected with his inventions? Look round the metropolis; our towns, —even our villages,—our dock-yards, and our manufactories; examine the subterraneous cavities below the surface, and the works above; contemplate our rivers and our canals, and the seas which surround our shores, and every where will be found records of the eternal benefits conferred on us by this great man. Our mines are drained, their products collected, the materials for our bridges

raised, the piles for their foundations sunk, by the same power; machinery of every kind, which formerly required an immensity of human labour, is now easily moved by steam; and a force equal to that of five hundred men is commanded by an infant, whose single hand governs the grandest operations. The most laborious works, such as the sawing of stones and wood, and raising of water, are effected by the same means which produce the most minute, ornamental, and elegant forms. The anchor is forged, the die is struck, the metal polished, the toy modelled, by this stupendous and universally applicable power; and the same giant arms twist the cable-rope, the protector of the largest ship of the line, and spin the gossamer-like threads which are to ornament female beauty. Not only have new arts and new resources been provided for civilised man by these grand results, but even the elements have to a certain extent been subdued, and made subservient to his uses; and, by a kind of philosophical magic, the ship moves rapidly on the calm ocean, makes way against the most powerful stream, and secures her course, and reaches her destination, even though opposed by tide and storm.

The Archimedes of the ancient world, by his mechanical inventions, arrested the course of the Romans, and stayed for a time the downfall of his country. How much more has our modern Archimedes done? He has permanently elevated the strength and wealth of this great empire; and, during the last long war, his inventions and their

application were amongst the great means which enabled Britain to display power and resources so infinitely above what might have been expected from the numerical strength of her population. Archimedes valued principally abstract science; James Watt, on the contrary, brought every principle to some practical use; and, as it were, made science descend from heaven to earth. The great inventions of the Syracusan died with him,—those of our philosopher live, and their utility and importance are daily more felt; they are among the grand results which place civilised above savage man,—which secure the triumph of intellect, and exalt genius and moral force over mere brutal strength, courage, and numbers. The memory of James Watt will live as long as civilised society exists; but it surely becomes us, who have been improved by his labours,—who have wondered at his talents and respected his virtues, to offer some signal testimony of our admiration of this great man. This, indeed, cannot exalt his glory, but it may teach those who come after us, that we are not deficient in gratitude to so great and signal a benefactor;—I therefore, my Lord, beg leave to move,—

"That the late James Watt, by the profound science and original genius displayed in his admirable inventions, has, more than any other man of this age, exemplified the practical utility of knowledge, enlarged the power of man over the external world, and both multiplied and diffused the conveniences and enjoyments of human life."

Mr. Boulton.—My Lord, I present myself to your notice, under the consciousness that, though I shall occupy a small portion of the time of this meeting, I shall need a large share of their indulgence, in my endeavours to lay before them a few illustrations of the genius and character of the individual, whose merits we are proposing to commemorate. Intimate as were my friendship and intercourse with Mr. Watt, through the whole of my life, and great as is my veneration of his unrivalled talents and merits, I am aware these considerations alone would not authorise me in asking any portion of the attention of the assembly I am now addressing: I am induced to hope for it solely under the idea, that my intimate acquaintance with the progressive introduction of the Steam Engine, and the application of it to our manufactures, may enable me to offer some observations connected with this view of the effects of Mr. Watt's great invention, not falling within the scope of the remarks of the distinguished President of the Royal Society. The philosophy and science of Mr. Watt's great and happy conception, have placed him in the first rank of the philosophers of his day; and his merits in embodying the principles of his invention in a perfect practical form, so as to render them most conducive to the extension of the nation's wealth, power, and comforts, are inferior only in the next degree to his eminent scientific attainments. At the period of the construction of the first steam engine upon his principles at Soho, the intelligent and judicious Smeaton, who had been invited to satisfy himself of the superior per-

formance of the engine by his own experiments upon it, and had been convinced of its great superiority over Newcomen's, doubted the practicability of getting the different parts executed with the requisite precision; and augured, from the extreme difficulty of attaining this desideratum, that this powerful machine, in its improved form, would never be generally introduced. Such was at that period the low state of the mechanic arts, as fully to justify his opinion; but a school of workmen, in every relevant branch, was speedily and successfully instituted, and the forms and construction of the machine were perfected with a skill and accuracy till then unknown in the execution of large machinery. A convenient and efficient instrument was formed, competent to give to every branch of manufacture the fullest developement; and, with the contemporary improvements of an Arkwright, a Wedgewood, and of many other distinguished manufacturers, several of whom are now before me, assembled to do honour to kindred genius and talents, arose a power, at once economical, regular, manageable, and almost of illimited force; in a word, an agent fitted in all respects to co-operate with the skill and enterprise of these distinguished men. The most effectual adaptation of this machine to the various operations of our diversified manufacturing establishments, was studied and accomplished; and what is now almost matter of routine, was, for a succession of years, attained by the continued efforts of a deeply reflecting mind, and by a series of ingenious experiments and researches throughout the whole scope of British

Manufacture. In this investigation, Mr. Watt had the co-operation of some highly enlightened colleagues, to whose merit and exertions he has paid a just tribute in his Report on the Steam Engine. It, however, is but justiee to say, that his comprehensive mind embraeed, with like sueeess, the minutest details, and the application of the most abstruse seienee. A power equal to that which would require the maintenance of one hundred thousand horses, has been furnished from the single establishment to whieh Mr. Watt belonged; and, assuming that power to be exercised during three hundred days in the eourse of the year, the saving arising from the substitution of steam power, in lieu of the exertions of the animals themselves, would not be less than three millions of pounds sterling per annum. Extending this calculation to the whole of the steam power produeed and used throughout the kingdom, we shall be supplied with a clear indieation to one of the sourees of power and wealth which have supported this nation through its late arduous struggle, and which have accelerated the renovation of its impaired energies, with a celerity exciting surprise in every refleeting mind. A corroborative inference will be derived from a comparison of the present and former states of some of the leading branches of our manufactures. The rapid extension of the cotton-trade has justly been observed, by the first authorities, to be unparalleled in the commercial annals of any country. Iron, of whieh we were large importers not many years since, is now extensively exported;

and, while the cotton produets of steam power are earried with advantage to the original site of this manufaeture in India, iron made by the same power, if unshackled by eommercial restrietions, might be plaeed on the quays of Petersburg in suceessful competition with that of Siberia. I am not therefore, I think, ineorreet in eoneluding, that the fortunate completion and introduetion of this useful and powerful instrument, in eonjunetion with the eontemporary efforts and talents of many of our distinguished manufaeturers, eneouraged and animated as they are by the enlightened poliey of our Government, have produced an era in our manufaetures and trade unexampled in any state or age, and one that will eonfer a conspicuous distinetion on this country in the history of empires. I am not either, I trust, aseribing an undue share of this prosperity and pre-eminence to the genius and merits of my late friend, Mr. Watt; and though I cannot divest myself of partiality for the memory of an individual, with whom I know it was esteemed by my father one of the highest distinetions of his life to have been associated; and the inheritor of this sentiment, if possible, still more deeply impressed, I anxiously hope I shall not be deemed to have been improperly influenced by this feeling, in seconding the resolution moved by the learned President of the Royal Society.

Mr. Huskisson.—My Lord, a task has been assigned to me at this meeting, which, I am fully aware, would have been far more ably and suceessfully exeeuted by some one of those, who have

done me the honour to put into my hands the resolution with which I shall conclude. Several of those gentlemen had an advantage, which I cannot boast, that of having been personally acquainted with the late Mr. Watt, of having enjoyed his confidence and friendship, and of having observed, more nearly than myself, the application and progress of those wonderful discoveries, and scientific inventions, by which he has so greatly benefited his country and the world.

But, gentlemen, however ill qualified I may be, fully to appreciate the merits of Mr. Watt,—however inadequate I feel myself to do justice to my own sentiments in this respect, I cannot but be gratified that I have a public opportunity to bear my humble acknowledgment of gratitude for his services, and of respect for his memory.

Gentlemen, whether, abstracting ourselves for a moment from all considerations of country, we look as men to the benefits which Mr. Watt's inventions have imparted, and are still imparting, to the whole race of man; or whether, as members of that great and powerful community of which he was a member, we confine ourselves to contemplate the special benefits which he conferred upon this country,—his great discoveries must stand equally entitled to our highest admiration. As Englishmen, we cannot behold the results produced by his genius, without a lively sense of joy that we belong to the same country to which he belonged; and without an individual feeling of gratitude that he lived at a time, which allows us all to partici-

pate in the benefits which he was the selected instrument, under Providence, of introducing among mankind.

If, gentlemen, there be any individual who can doubt whether Mr. Watt be entitled to rank in the first class of the benefactors of mankind, that individual, let him belong to what station of society he may, has, I think, not justly estimated the influence of improvements in physical and chemical science upon the moral condition of society. I apprehend no man can doubt the beneficial effect of that influence, more or less, in all civilised countries. But, in my view of the subject, there is no portion of the globe, however remote, where the name and flag of England are known, where commerce has carried her sails, and begun to introduce the arts of civilisation, which does not derive some advantage from Mr. Watt's discoveries. The economy and abridgment of labour, the perfection and rapidity of manufacture, the cheap and almost indefinite multiplication of every article which suits the luxury, the convenience, or the wants of mankind, are all so many means of creating, in men even but little advanced from the savage state, a taste for improvement; of raising in their bosoms a feeling of new wants and new desires; of shewing them the possibility of satisfying those wants and those desires; and thereby of calling into action the most powerful stimulant, and steady motive, to advancement in the scale of the civilised world. Are not the remote islands of the Pacific Ocean become a happy proof of the truth of this

position? The same race which, less than half a century ago, murdered and devoured our intrepid but unfortunate navigator, Captain Cook, have, within that short period, become acquainted with many of the comforts of life, and made a greater progress, perhaps, towards improvement than remains for them to make, in order to entitle themselves to be admitted into the rank of civilised nations. Much of this happy change may, I grant, be ascribed to the benevolent and indefatigable exertions of the ministers of Christianity; but, if these islanders be now clothed in the productions of English industry,—if they have adopted our woollens and our linens, instead of their own rude dress (or rather no dress),—if in their habitations are to be found many useful articles of English manufacture, instead of their own barbarous utensils,—let it not be supposed that the increased facility of supplying their wants has not been one powerful means of exciting their desire to procure these enjoyments. If the Steam Engine be the most powerful instrument in the hands of man, to alter the face of the physical world, it operates at the same time, as a powerful moral lever in forwarding the great cause of civilisation. We cannot, therefore, recall to our recollection the invention of the Steam Engine, and follow that invention through all its consequences, without feeling the beneficial influence of this discovery upon all nations, from those most advanced, to those which have made the least progress, in the arts and refinements of life.

The benefits which this discovery has conferred upon our own country, as they are more extensive, are also more obvious. If this were the proper place, and if I were not afraid of trespassing too long upon your time, I could trace those benefits in their detailed progress and operation. I could show how much they have contributed, not only to advance personal comfort and public wealth, by affording to industrious millions the facility of providing for their individual wants, by means which directly conduce to the general power and greatness of the state,—but also to the general diffusion of a spirit of improvement, a thirst for instruction, and an emulation to apply it to purposes of practical utility, even in the humblest classes of the community. But it cannot be necessary to enter upon so wide a range, with the enlightened meeting which I have now the honour of addressing. Looking back, however, to the demands which were made upon the resources of this country during the late war, perhaps it is not too much to say, at least it is my opinion, that those resources might have failed us, before that war was brought to a safe and glorious conclusion, but for the creations of Mr. Watt, and of others moving in the same career, by whose discoveries those resources were so greatly multiplied and increased. It is, perhaps, not too much to say, that, but for the vast accession thus imperceptibly made to the general wealth of this empire, we might have been driven to sue for peace, before, in the march and progress of events, Nelson had put forth

the last energies of his naval genius at Trafalgar, or, at any rate, before Wellington had put the final seal to the security of Europe at Waterloo. If, therefore, we are now met to consider of placing a monument to the memory of Mr. Watt beside the monuments of those who fell in the splendid victories of the last war, let it not be said that there is no connexion between the services of this modest and unobtrusive benefactor of his country, and the triumphs of the heroes which those monuments are destined to commemorate.

I own that the monument about to be proposed to Mr. Watt appears to me to be one of those acts of public duty, to which every Englishman of a cultivated mind, following the munificent example of the sovereign, should be anxious to contribute. In doing so, he will indulge not only a feeling of gratitude, but the cheering hope of exciting a spirit of emulation in others; and an honest pride, in reflecting that he belongs to the same community of which this highly-gifted genius was a member, and to the age in which he lived.

Long as I have already detained the meeting, I cannot sit down without adding one or two short remarks. It has been often said, that many of the great discoveries in science are due to accident; but it was well remarked by the President of the Royal Society, that this cannot be the case with the principal discovery of Mr. Watt. Long and scientific research and application alone could have enabled him to create his Steam Engine. Again, it has frequently happened that those philosophers, who

have made brilliant and useful discoveries, by watching the phenomena of the physical world, the combinations of chemistry, or the mysterious workings of organic life, have only been able to turn their discoveries to the purpose of averting evils threatening, and often destroying, the precarious tenure of human existence. Thus Franklin disarmed the thunderbolt, and conducted it innocuous through our buildings, and close to our fire-sides; —thus Jenner stripped a loathsome and destructive disease of its virulence, and rendered it harmless of devastation;—thus the present President of the Royal Society, (of whom it is difficult to say whether abstract science or practical life has been most benefited by his discoveries), sent the safety lamp into our mines, to save, (as its name implies,) their useful inhabitants from the awful explosion of the fire-damp. But the discovery of Mr. Watt went further; he subdued and regulated the most terrific power in the universe; that power which, by the joint operation of pressure and heat, probably produces those tremendous convulsions of the earth, which in a moment subvert whole cities, and almost change the face of the inhabited globe. This apparently ungovernable power Mr. Watt brought into a state of such perfect organization and discipline, (if I may use the expression), that it may now be safely manœuvred and brought into irresistible action,—irresistible, but still regulated, measured, and ascertained,—or lulled into the most complete and secure repose, at the will of man, and under the guidance of his feeble hand. Thus, one man directs it into the bowels of the earth, to tear

asunder its very elements, and bring to light its hidden treasures ; another places it upon the surface of the waters, to control the winds of heaven, to stem the tides, to check the currents, and defy the waves of the ocean ;—a third, perhaps, and a fourth, are destined to apply this mighty power to other purposes, still unthought-of and unsuspected, but leading to consequences, possibly, not less important than those which it has already produced.

It is, gentlemen, in the contemplation of the wonderful, but most beneficial change which this single invention has already effected in the world, —in the anticipation of the still further changes which it may effect, that I feel most forcibly my own want of power to do justice to my sentiments on this occasion, and that I gladly relieve myself from any further prosecution of the attempt by proposing to you the following Resolution :

" That those benefits conferred by Mr. Watt on the whole civilised world, have been most experienced by his own country, which owes a tribute of national gratitude to a man who has thus honoured her by his genius, and promoted her well-being by his discoveries."

Sir James Mackintosh.—Lord Liverpool, and gentlemen, I rise to perform the duty which has been allotted to me, in seconding the resolution which has just been proposed. I am perfectly aware how needless it is for me to address you, after what you have heard from persons of whom each had some peculiar claim on your attention. But, even if I could be silent without disrespect to you,

I will own that I should find it difficult to decline what I consider as so high an honour, as that of taking a part in the present proceeding.

The character of Mr. Watt has already been presented to you in a double point of view. Had he been only a discoverer in science, his name would have been immortal in the annals of philosophy. Had he been only a fortunate inventor in the useful arts, his name would have marked an epoch in the progress of ingenious industry. But when we consider him as combining both these characters; when we consider him as a great discoverer, who applied the results of his own philosophical discoveries to the purposes of human life, so as to convert an obscure and neglected engine into a power which has beneficially changed the face of the world, I think I may safely join my voice to those more powerful voices which have preceded me, in affirming, that no man ever had a more evident claim to be honoured by his country, and reverenced by all generations.

The debt of science has been eloquently paid by the President of the Royal Society. No man now living is so well entitled to appreciate great discoveries; and no man's presence can more strongly remind others of the honours, and, (if need be), of the rewards which are due to those who apply their great discoveries to the immediate service of their country. The debt of the state has been becomingly paid by the ministers of the crown; who have truly told you, that those vast inventions which are in due time to become the property of

all mankind, served in the first instance to multiply the resources of our own country, to arm her with new strength, to enable her to sustain more arduous and perilous contests than any in which she had been before plunged, and to rouse the energy and talent of others who were excited by the genius of Watt, to follow, though at a distance, in the footsteps of their master.

The President of the Board of Trade has justly and happily described the moral power of these physical discoveries; their effect, not only in spreading among the humblest classes of civilised communities what were formerly the ornaments and luxuries of the rich, but in benefiting those savage tribes who seem, at first sight, beyond the reach of those benefits conferred on civilised men, by presenting new gratifications to them, accessible even to their poverty; by awakening new desires, inspiring new faculties, and insensibly, as it were, tempting them into a career of improvement from which they appeared to be for ever debarred.

It may be presumptuous in me to add any thing in my own words, to such just and exalted praise. Let me rather borrow the language in which the great father of modern philosophy, Lord Bacon himself, has spoken of inventors in the arts of life. In a beautiful, though not very generally read fragment of his, called the New Atlantis, a voyage to an imaginary island, he has imagined an University, or rather Royal Society, under the name of Solomon's House, or the College of the Six Days' Works; and, among the various buildings

appropriated to this institution, he describes a gallery destined to contain the statues of inventors. He does not disdain to place in it, not only the inventor of one of the greatest instruments of science, but the discoverer of the use of the silkworm, and of other still more humble contrivances for the comfort of man.—What place would Lord Bacon have assigned in such a gallery to the statue of Mr. Watt? Is it too much to say, that, considering the magnitude of the discoveries, the genius and science necessary to make them, and the benefits arising from them to the world, that statue must have been placed at the head of those of all inventors in all ages and nations! In another part of his writings, the same great man illustrates the dignity of useful inventions by one of those happy allusions to the beautiful mythology of the ancients, which he often employs to illuminate as well as to decorate reason. "The dignity," says he, "of this end of endowment of man's life with new commodity, appeareth by the estimation that antiquity made of such as guided thereunto; for whereas founders of states, lawgivers, extirpators of tyrants, fathers of the people, were honoured but with the titles of demigods, inventors were ever consecrated amongst the gods themselves*."

* The sequel of this passage is singularly applicable to the nature of Mr. Watt's service:—"And if the ordinary ambitions of men lead them to seek the amplifications of their own powers in their countries, and a better ambition hath moved men to seek the amplification of the power of their own countries amongst other nations; better again and more worthy must that aspiring be which seeketh the amplification of the power and kingdom of mankind over the

It has been justly observed, that no invention, equally great and useful, ever sprung so much from the science of the inventor, as the application of the power of steam. It is, doubtless, this peculiarity which exalts the name of Mr. Watt above most of those who went before him. But it may be considered from a higher point of view, as marking the advancement of the human mind, and justifying hopes of its farther progress. The improvements, great and valuable as they are, which have owed their origin to fortunate circumstances, and to the unscientific sagacity and ingenuity of individuals, are irregularly scattered over a long series of ages. It is impossible to reduce their progress to any definite and precise laws ;—you cannot foretell with certainty that one discovery will soon be followed by others : at most, you can only trace a faint outline of the general advances of mankind. But it is otherwise with scientific discoveries ; they show, that knowledge has reached that period of maturity when she becomes fruitful. Every such discovery is the parent of future discoveries ;—every advance so made, gives us a clearer view of the remainder of the road, and we may venture in some degree to conjecture what is to come, by looking back on what has been. Sixty years only,—(how short a

world ; the rather because the other two prosecutions are ever culpable of much perturbation and injustice : but this is a work truly divine, which cometh *in aura leni* without noise or observation."—Fragments of Valerius Terminus, on the Interpretation of Nature.

period in the history of philosophical invention!)—sixty years only have passed, since the great discovery of Watt. Scarce forty years have elapsed, since it has been reduced to practice on an extensive scale. You have heard from a gentleman,* in whose presence it is delightful to take a part in this national homage, the mighty effects which it has produced in that little time. It has been calculated by a most ingenious foreigner, (M. Dupin,) that the power of the Steam Engines in England alone, which are managed by thirty-six thousand men, would have been sufficient in eighteen hours to raise the great pyramid of Egypt, which is said to have cost the labour of one hundred thousand men for twenty years. If we survey the face of the globe, we see the same discovery everywhere;—wherever we turn our eyes, from the Missouri to the Ganges, the earth is already covered with monuments of the genius of Watt. The summits of the Andes are crossed by his machines;—the mines of Mexico are about to yield a more abundant produce, under the mighty action of the power which he has revealed. The seas and rivers swarm with those new vessels which we owe also to his genius; for it was he who rendered it possible to apply steam with advantage to navigation. It was but the other day I heard that the vast rivers of South America are to be navigated by steam vessels, and that the savages who crawl in the marshy forests of Guiana, will soon be roused to a sort of

* Mr. Boulton.

stupid amazement, by the sight of vessels making their way against the stream of the Orinoco, without any visible impulse from nature or from human labour.

If such has been the result of a single discovery in sixty, or rather in forty years, what may not sanguine hope whisper to itself, of the probability of approaching improvements? Had any man predicted in 1784 what we have seen accomplished by the genius of Watt, his prophecy would have appeared more extravagant, than the most brilliant visions of futurity in which we could now indulge. In contemplating such glorious victories of intellect over Nature, I own I sometimes venture to cherish trembling hopes of physical and even moral improvements, which I should not dare to expose to the eye of the scorner. I cannot but believe that glorious things yet lie hidden in the unopened volumes of the destinies of man. Let me add, that the alliance of philosophy with the useful arts, is not only of great value to society, but, in more than one respect, of the utmost importance to science itself. The President of the Royal Society will allow me to say, that every manufactory may thus become, in some degree, a school of experimental philosophy. No experiments are so decisive as those processes, which, being performed for personal advantage, can only be continued while they are successful. There are no other means of showing the palpable utility of knowledge to the most ignorant, and of rendering it respectable to the grossest and rudest of men. Thus it becomes

popular ; it is spread through a greater number of understandings ; it visits minds which, though doubtless possessing their proportion of acuteness and vigour, would not otherwise have been lifted above the most vulgar concerns of mere animal existence. The chances of the advancement of science are increased, in proportion to the additional number of intellects engaged in its cultivation. The collective understanding of mankind is invigorated, their talents are excited by competition and collision, and their minds are elevated by a glimpse, however imperfect, of higher objects. These reflections were very strongly impressed on my mind when, in company with my learned friend near me,* I lately went to visit the Mechanics' Institution,—a species of establishment first founded at Glasgow, by Dr. Birkbeck, and lately introduced into the capital by the same very meritorious person. I was present at a lecture delivered there to eight hundred working mechanics, on the laws of attraction ; a subject, apparently, (though only in appearance,) far remote from their occupations. Their appearance exhibited all the sobriety, cleanliness, and comfort, which are the happy marks of contented industry ; and they listened with as much intense attention and evident intelligence as could be shown by an audience of philosophers. When the lecturer came to explain the important law according to which the force of attraction decreases, in proportion to the squares of the dis-

* Mr. Brougham.

tances, the interest of the audience seemed to become stronger, until, when he had at length completed his illustrations, as well as his proofs, an unanimous plaudit burst forth from the delighted audience,—the pure fruit of pleasure, in seeing the new truth then for the first time revealed to their understandings. A more intellectual plaudit never arose from any assembly of men;—it was an applause worthy of reasonable beings, for it could only have arisen from the comprehension of a new and sublime truth. If it had not been perfectly understood, it could have given no pleasure. I was struck and even affected by the consideration, that within a century of the death of Newton, in the capital which he honoured by his residence, his most sublime discoveries could be thus rendered intelligible and delightful to eight hundred working mechanics. I could not look on that body of men, without reflecting on the importance of casting the seeds of knowledge into their minds, and how much these new votaries of Science may contribute to strengthen and enrich their country, while they spread improvement and enjoyment over the world. Every principle disclosed to them, every accession to their knowledge, every stimulant applied to their faculties, may produce consequences yet unimagined, in the solitudes of New Holland, or even in the unexplored deserts of Africa.

We have survived a prejudice prevalent among speculative men, though in itself shallow and vulgar, that knowledge loses some part of its dignity

when it becomes directly useful; and we are now convinced, with Bacon, (who was assuredly not influenced by any defect of fancy or elevation,) that science is ennobled, not degraded, by bringing forth a numerous progeny of useful arts. We have survived, also, another prejudice equally vulgar, though of an opposite kind, which induces some to undervalue the elegant arts, as if they also were not useful. We may continue to distinguish between the fine arts and the useful arts, but we must not oppose them. It is as absurd to question the genius of Watt, as to doubt the usefulness of Chantrey and Lawrence. The fine arts must always be useful. The useful arts may often exhibit the same beauty and greatness which are displayed in the fine. Wherever an original mind produces new combinations of thought and feeling, whether its means be words or colours, or marble or sound, or command over the mighty agents of nature; whether the result be an epic poem, or a statue, or a Steam Engine, we must equally reverence those transcendant faculties to which we give the name of genius.

I rejoice at seeing here, on this occasion, some of the friends and companions of Mr. Watt, and many of that enlightened, ingenious, independent, and upright class of men, the manufacturers of England; who will consider this meeting as a public solemnity in honour of the useful arts, as a just honour paid to their respectable body, in the person of him who was indisputably at their head. The descendants of Wedgewood, and Arkwright, and Rennie, cannot

behold with indifference the honours paid to the memory of Watt. In reflecting on the qualities which are often common to the fine and useful arts, I feel pleasure that the proposal to honour the memory of this great man should be made in the year in which a gallery of paintings is for the first time opened in this greatest of cities, not for the splendour of monarchy or the dignity of aristocracy, but for the cultivation and gratification of the whole people of England. I also draw a happy augury for our success, from the circumstance, that our design is undertaken at the moment when we have seen the genius of Chantrey draw forth, from marble, the lineaments of wisdom and benignity which once marked the living countenance of Watt.

Mr. Brougham.—My Lord and Gentlemen, I cannot but feel, in common with those who have addressed you, the honour of being permitted to take a part in these proceedings, by proposing a resolution, which has for its purpose, to embody, in a practical form, the sentiments entertained, I trust unanimously, by this meeting. I presume that I owe this distinction to the circumstance of having been a humble, though a zealous promoter, in conjunction with a worthy and learned friend of mine, (Dr. Birkbeck,) whom I saw a little while ago in this place, of the institution alluded to by my honourable friend who preceded me, the object of which is to bring science within the reach of the humblest artisan in this country, and the effect of which in all probability will be, to draw forth

many a man of genius from the most numerous and important class of society, to follow in the footsteps of him, whose name, once obscure, now shines forth with so brilliant and so useful a lustre.

But there is another ground upon which I presume to address this meeting. I had the happiness of knowing Mr. Watt for many years, in the intercourse of private life; and I will take upon me to bear a testimony, in which all who had that gratification I am sure will join, that they who only knew his public merit, prodigious as that was, knew but half his worth. Those who were admitted to his society will readily allow, that any thing more pure, more candid, more simple, more scrupulously loving of justice, than the whole habits of his life and conversation proved him to be, was never known in society. One of the most astonishing circumstances in this truly great man, was the versatility of his talents. His accomplishments were so various, the powers of his mind were so vast, and yet of such universal application, that it was hard to say whether we should most admire the extraordinary grasp of his understanding, or the accuracy of nice research with which he could bring it to bear upon the most minute objects of investigation. I forget of whom it was said, that his mind resembled the trunk of an elephant, which can pick up straws, and tear up trees by the roots. Mr. Watt in some sort resembled the greatest and most celebrated of his own inventions; of which we are at a loss whether most to wonder at the power of grappling with the migh-

ticst objects, or of handling the most minute; so that, while nothing seems too large for its grasp, nothing seems too small for the delicacy of its touch; which can cleave rocks and pour forth rivers from thc bowels of the earth, and, with perfect exactness, though not with greater ease, fashion thc hcad of a pin, or strike the impress of some curious die. Now, those who knew Mr. Watt had to contemplate a man whose genius could create such an engine, and indulge in the most abstruse speculations of philosophy, and could at once pass from the most sublime researches of geology and physical astronomy, the formation of our globe, and the structure of the universe, to the manufacturc of a needle or a nail; who could discuss in the same conversation, and with equal accuracy, if not with the same consummate skill, the most forbidding details of art, and the elegances of classical literature; thc most abstruse branches of scicncc, and the niceties of vcrbal criticism.

There was one quality in Mr. Watt which most honourably distinguishcd him from too many inventors, and was worthy of all imitation,—he was not only entirely free from jealousy, but he exercised a careful and scrupulous self-denial, and was anxious not to appcar, even by accident, as appropriating to himsclf that which he thought belongcd to othcrs. I havc heard him refusc thc honour univcrsally ascribed to him, of being thc inventor of the Stcam Engine, and call himself simply its improver; though, in my mind, to doubt his right to that honour would bc as inaccuratc as to ques-

tion Sir Isaac Newton's claim to his greatest discoveries, because Des Cartes in mathematics, and Galileo in astronomy and mechanics, had preceded him; or to deny the merits of his illustrious successor, because galvanism was not his discovery, though before his time it had remained as useless to science, as the instrument called a Steam Engine was to the arts before Mr. Watt. The only jealousy I have known him to betray, was with respect to others, in the nice adjustment he was fond of giving to the claims of inventors. Justly prizing scientific discovery above all other possessions, he deemed the title to it so sacred, that you might hear him arguing by the hour to settle disputed rights; and if you ever perceived his temper ruffled, it was when one man's invention was claimed by, or given to another; or when a clumsy adulation pressed upon himself that which he knew to be not his own.

It is fit that we should now act in this spirit of justice towards him, and discharge, as far as we can, our debt of gratitude, by erecting a monument to his memory.—To perpetuate his name, indeed, there needs no monument of perishable materials,—it will be as lasting as that element which he subdued to the use of man; but at least, by consecrating his renown in the eyes of the people, we may hold forth his example to others in that rank of life from which his genius taught him to rise, and demonstrate that a man of talent in humble life cannot more certainly command the gratitude of his country, than by devoting himself

to pursuits which tend towards the common benefit of mankind. And I think I may add, in reference to the last part of the resolution with which I am about to conclude, that this memorial of our admiration cannot be more fitly placed than within walls raised to that religion which teaches universal peace, and, with a peculiar care, cherishes the rights of the poor. If, in old times, the temples of false gods were appropriately filled with the images of men who had carried devastation over the face of the world, surely our temples cannot be more worthily adorned than with the likenesses of those whose triumphs have been splendid indeed, but unattended by sorrow to any,—who have achieved victories, not for one country only, but to enlarge the power and increase the happiness of the whole human race:—I move,

"That a monument be erected to the memory of the late Mr. Watt in the Cathedral Church of Saint Paul, or in the Collegiate Church of Saint Peter, Westminster, and that a subscription for that purpose be forthwith opened."

Mr. Littleton.—My Lord Liverpool and Gentlemen, you will easily give me credit when I assure you, that it is with extreme diffidence I offer myself to your attention after the gentlemen you have heard this day; but still, so great is my admiration of Mr. Watt's talents and character, that I cannot deny myself the satisfaction of occupying your time a few moments, while I second the resolution which you have just heard put. For certain I am, that among those records of in-

dividual distinction and of national fame contained in that sanctuary which has been referred to in the resolution, there will be none, the justice and propriety of which the English public and the whole world will more willingly acknowledge, none that will be inscribed with a name to which Englishmen, in the natural spirit of national rivalry and pride, will more fondly point, than that which shall bear upon it the name of Watt; for never, hitherto, has there existed a country in the world, that could boast of having given birth to a man, who, by the sole force of his own philosophic genius, has conferred such benefit, not only upon his own country, but upon mankind at large, as have resulted from the inventions of Mr. Watt. Although the grand invention of the separate condenser in the Steam Engine may be dated so far back as sixty years ago, yet it was not till the year 1784 that its adaptation to rotatory machinery was perfected; and it is from that period we may trace all the great results that have followed to our country and to the world.

I have been anxious to procure some data, on which to form an estimate of the probable number and power of the Steam Engines in this island; and I am assured, that the data on which M. Dupin has founded his calculations are nearly accurate. It is stated by him, that the amount or number of Steam Engines in England is somewhere about ten thousand. Taking these, on an average, to be equal to twenty horse power each, we have 200,000 horses acting together, for the total force employed

in manufactories, mines, &c. during a period of from ten to twenty-two hours each day. There must be at least from two to two and a half sets of horses kept to perform a work of this description, which would raise the total number equivalent to the ten thousand Steam Engines, to from *four to five hundred thousand horses!* The difference of cost between the coals consumed by these engines and the keep, &c. of the above number of horses, would amount *to above fifteen millions of pounds sterling annually.* And, if this calculation was carried farther, so as to set before you an idea of the annual saving in human labour through the medium of these 10,000 Steam Engines, the result would be so prodigious as to be hardly credible to any one. My Lord, as the representative of that county which witnessed the earliest and most extensive application of Mr. Watt's invention, it has frequently occurred to me to reflect on the prodigious change which, in a few years, almost within my own memory, has been wrought on the face of that country. By the agency of Mr. Watt's inventions, minerals have been raised with a facility and in an abundance adequate to the supply of every part of the world; by the power of Mr. Watt's mind, lands which had lain waste, or were occupied by a solitary tenantry, have been covered with towns, daily extending their limits, and uniting with each other, and the whole face of the country is seen glowing with industry, intelligence, and wealth. Surely, then, it is due that we should take some public step to record our gratitude for

such services. Had Mr. Watt been living, such a measure, gentlemen, would have been unnecessary. You have heard from those who had the happiness of his personal acquaintance, that in his manner and habits of life he was one of the simplest of men. Equally devoid of ostentation and of jealousy, he was, in all the affections of the heart, one of the kindest and most philanthropic of his kind. He ambitioned no other monument than that which his own genius had created;—he aimed at no other reward than the consciousness that no man in former times had promoted to an equal extent the wealth and power of his country, or contributed so largely to improve the condition of his fellow-men. But we have a duty to discharge. We owe it to his son, to his relatives, to his friends, above all, we owe it to ourselves, that we should unite in recording our sense of the inestimable value of the benefits we have received from him. It is incumbent upon us as a nation, to proclaim to the world that it is in the production of such characters that we place our chief pride. I beg leave, my Lord, to second the Resolution.

The Right Hon. Mr. Secretary Peel.—Although, gentlemen, no one feels more strongly than I do, that so far as human intellect can do justice to the merits of Mr. Watt, that justice has been done, and that it is perfectly hopeless in any one, and perhaps presumptuous, to attempt to add to what has fallen from those who have addressed this assembly, yet, I trust, from the peculiarity of my situation, I may be heard for a few

moments. I say the peculiarity of my situation, because I differ from those who have preceded me, in this respect,—that I belong to that very numerous class of persons who have derived a direct personal benefit from the important discoveries of Mr. Watt. Gentlemen, I am one of those who derive all that they possess of worldly prosperity from the honest industry of others; and that man must have a base and ungenerous mind, who, upon such an occasion as this, (such an awful and affecting occasion), could refuse to acknowledge his origin and his obligations, with any other feelings than those of satisfaction and pride.

The branch of industry of which I am particularly speaking, is that fruitful source of our national wealth,—the cotton manufacture of this country.

That manufacture, important as it was before, received new life and spirit from the discoveries of Mr. Watt.

I believe that it was in the year 1790 that the first Steam Engine, which applied a rotative power to machinery, was erected in the town of Manchester.

Before that period, the cotton manufacture had been chiefly carried on in remote, and, comparatively speaking, inaccessible places.

It was dependent for its support either upon animal power, or upon unassisted nature; but the inventions of Mr. Watt gave it an energy, which effected a complete revolution in the trade. It was transferred, from wild and thinly inhabited

districts, to the centre of population and industry. Each branch of the trade, which before had been separately carried on, is now brought together; and so perfect is the combination, that I understand it is possible to see within the same room, and in an inconceivably short space of time, every process conducted, by which the raw produce is transformed into the most beautiful fabric that adorns the female form.

When I recollect what has taken place in that county since the year 1790, in the short space of thirty years,—when I look at the individual fortunes that have been made,—the new towns that have sprung into existence,—the thousands of human beings that have been born, who, but for the discoveries of Mr. Watt, would never have seen the light, I am lost in admiration, not so much of the powers of mind of Mr. Watt, as of the dignity of human nature, which is ennobled by discoveries like these, that give subsistence to thousands, while they widen the limits and add to the strength of the empire.

It is, therefore, my Lord, with the most heartfelt satisfaction that I give my warmest support to the proposition for erecting a Monument to the memory of so great a man. I feel an obligation to him from higher considerations, than those of the wealth to which he may have contributed. I feel the class of society from which I derive my origin, exalted and honoured, by possessing such a man among its ranks.

I hope the result of this meeting will be even to improve upon that suggestion of Lord Bacon, which has been noticed by Sir James Mackintosh.

I hope, that to inventors like Mr. Watt, we shall have no separate gallery appropriated in which we may perpetuate their fame; but that the same dome which now covers the monuments of the warrior, and of the poet, and of the statesman, of those whom I must consider *concordes animæ*, will protect also the memorials which a grateful nation may raise to the men who have perfected the arts of civilised life, and have thus done lasting honour to their country.

The Resolution was then put by the noble Chairman, and carried unanimously.

The Earl of Aberdeen.—My Lord and Gentlemen, in moving this Resolution, which has been placed in my hands, it would ill become me to attempt to add to the eulogy which you have already heard on the distinguished individual whose genius and talents we have met this day to acknowledge. That eulogy has been pronounced by those whose praises are well calculated to confer honour, even upon him whose name does honour to his country. I feel in common with them, although I can but ill express that intense admiration which the bare recollection of those discoveries must excite, which have rendered us familiar with a power before nearly unknown, and which have taught us to wield, almost at will, perhaps the mightiest instrument ever intrusted to the hands of man. I feel, too, that in erecting a Monument to

his memory, placed, as it may be, among the memorials of kings, and heroes, and statesmen, and philosophers, that it will be then in its proper place; and most in its proper place, if in the midst of those who have been most distinguished by their usefulness to mankind, and by the spotless integrity of their lives.

Gentlemen, it is obvious that, in order to carry your intentions into full effect, it will be necessary to commit the management of this work to persons qualified, by their acquirements and knowledge, to superintend its execution in such a manner as may do justice to your enthusiasm and to the object in view. I beg therefore to move,

"That a Committee (of which you will hear the names hereafter) be appointed for this purpose."

Mr. Frankland Lewis.—I am aware that the honour of being called upon to second this resolution has been conferred upon me for no other reason, than because I had the good fortune to be acquainted with Mr. Watt in private life. I rise therefore under impressions which I am sure must be deeply felt by all those around me who were his personal friends, and which incline me rather to express the delight and satisfaction with which I have listened to the just eulogies which have been pronounced upon his name, than to attempt to add to them by any feeble words of my own. It would indeed be a gratifying duty to dwell on his excellent qualities, and the benefits which he has conferred on mankind; and if I could at this moment be induced to do so, I might be encouraged in the

attempt by the recollection of the peculiar mildness of manner and benevolence of disposition which distinguished that lamented individual, and prevented persons of inferior capacities from being overwhelmed in their communications with him, by the extent of his knowledge and the superiority of his mind. There is nothing more true in what has been said of him to-day, than that they who have looked at Mr. Watt only in the light of a philosopher and an inventor, know in reality but a small portion of the worth and excellence with which he was adorned: amongst other qualities, he was distinguished by an intense power of thought, which was alike upon all the various subjects to which his extended studies and cultivated taste were constantly applying it. I perceive, however, that I am falling into needless repetition, and will content myself with bearing my testimony to the perfect accuracy of that admirable record of his character, for which we are indebted to the pen of Mr. Jeffrey. It must to many persons have appeared to be a flattering eulogy; it is, in fact, no more than a plain, unexaggerated statement.

With this consciousness of Mr. Watt's merits, and of the benefits he had conferred on mankind, it had occurred to many persons towards the close of his life, that the public had been slow in acknowledging the services he had rendered; and I myself, in common with others, more than once openly expressed my wishes, that some mark of public gratitude might be bestowed on him in his lifetime. That this object was not effected, is attributable

rather to the circumstances of the times, than to a tardiness in recognizing Mr. Watt's services. It must not be forgotten, that Mr. Watt did not long survive that protracted and eventful contest, in which this country was for so many years engaged with the disturber of the peace of Europe; and, whilst that contest lasted, the attention of the public was directed, and its honours chiefly bestowed, on those who were struggling, at the hazard of their lives, to extend the glory and to secure the liberties of their country. That contest, however, has been fortunately closed. Our attention is now turned to pacific objects, and, in contemplating the gratifying spectacle which this country now affords; its peaceful, orderly, and hourly increasing industry, the effects and example of which are felt in the remotest corners of the habitable globe:—who is there who does not see, that for the power which sets all this in motion we are indebted to the discoveries of Watt? It is to this period, therefore, and to the present circumstances of the country, that the due estimation of his services must necessarily belong.

The Committee, whose names are about to be read, will have the grateful task of preparing a Monument which may, if possible, be worthy of his fame. They will, no doubt, succeed in executing a work alike honourable to the feelings, and creditable to the taste of the country. It will, however, be rather a testimony of our admiration, and a tribute of our gratitude, than a means of prolonging his memory: the hands of man cannot

construct a monument so durable as the name of Watt.

Lord Liverpool.—Before proposing this Resolution, I wish to state that I hold in my hand a letter from Mr. Canning, in which that right honourable gentleman regrets that he is unable to attend, owing to a press of public business; and states his cordial approbation of the purpose of the meeting, and his desire of giving it every effect.

The Resolution being then put by the noble Chairman, was carried unanimously.

Mr. Wedgewood.—My Lord Liverpool, and Gentlemen, I am perfectly aware that I have no sort of claim to present myself to your notice, except that of having been selected in the course of the arrangements usual on such occasions, to make a motion; and I shall not trespass upon your time by entering upon the subject before the meeting, because, by so doing, I could only weaken the effect of what you have heard. I beg leave, however, to express the pleasure that I feel in being the organ, as the temporary representative of the body to which I belong, the manufacturers of Great Britain, of conveying to your Lordship their thanks for the honour your Lordship has done them, in presiding this day on an occasion so interesting to them; and I trust I may be farther allowed to indulge myself, in the expression of my personal gratitude, and my respect and admiration for the great man whose memory we are met to celebrate:—I move

"That the thanks of this meeting be given to

the Right Honourable the Earl of Liverpool, &c. &c."

Mr. Wilberforce.—My Lord, Although I abundantly participate in the sentiments and feelings which have been so powerfully expressed by those who have gone before me, and rejoice in the opportunity with which I am honoured, of publicly declaring my sense of the claim of that extraordinary man, the late Mr. Watt, to the admiration and gratitude of his country, the duty which I have to discharge is not so much that of paying to his character my willing tribute of applause, as to express the satisfaction which I feel in seeing the first minister of the Crown occupying the chair this day, as the just representative of our gracious Sovereign; and, at the same time that he expresses his own feelings, conveying to us those of his royal master. I congratulate you, my Lord, on the proof you hereby afford, that you recognise the just use to be made of superior rank and station. Well, indeed, does it become your Lordship to come forward on the present occasion; and in your Sovereign's name, as well as in your own, to call upon the nation at large to testify the respect that is due to the character of that great man, whose claims to public distinction we are now commemorating. The duty you have to perform, my Lord, is no less, I am persuaded, enforced on you by the sense of duty, than it is congenial to your personal feelings: for as one who from your public station cannot but take a peculiar interest in the well-being and prosperity of your country, you cannot but delight in acknow-

ledging the superior merits of Mr. Watt, and his just claim to the honour we are now about to assign to him. For his extraordinary talents were not exerted for his own advantage or reputation only, but have already been, and are likely to be to a still greater extent, conducive to the prosperity and aggrandisement of his country. It has been truly remarked, that praise is doubly valuable when it proceeds from one who is himself eminently deserving of it: and it has been Mr. Watt's peculiar good fortune on this day to verify the remark. His services have been this day celebrated by those who are peculiarly well qualified to appreciate their value. The President of the Royal Society in particular, in specifying Mr. Watt's claims to distinction, and in explaining the nature and merits of his inventions, pursued his course with such admirable distinctness and perspicuity, as to shed a light all around him in his progress, and to make persons as little conversant as myself with scientific subjects, feel, for the time, that they clearly understood the nature and merits of his discoveries. It was stated to be one of the honourable peculiarities of Mr. Watt's character, that he was a stranger to that jealousy which it has been too often humiliating to detect in men of high reputation; and it has been delightful to find the same spirit pervading the meeting this day, and especially to have heard such a full measure of commendation bestowed on Mr. Watt, by one who has himself attained such just and honourable distinction, and to whom, on a future,—may it be a distant day!—posterity

will assign the same honours which he now calls upon us to pay to a departed brother in the paths of philosophical invention.

May I be permitted also to express a gratification of another kind, which I cannot but feel in witnessing the proceedings of this day. I see myself surrounded by men of the most opposite political opinions; by those whom the different judgments they form of public events, whose different views of national interest, too commonly lead into contention and debate;—how gratifying is it to find, that in such a duty as is this day to be performed, all political distinctions are forgotten! We seem to rise into a higher region of light and truth, of genius and of science, where none of those passions darken, and none of those baser emotions discompose the atmosphere, that are generated in the scufflings of the vale below; without a discordant opinion, we gladly unite in recognising and applauding that merit which raised its proprietor to wealth and glory; which diffused its genial influence throughout the country at large, and, while, in a thousand channels of individual industry, it multiplied the comforts of individuals, it added to the stock of national wealth and greatness. It is the glory, my lord, of the country in which we live,—a glory to which in the whole history of the world no country was ever before entitled in so eminent a degree,—that individuals, by the honourable exercise of their own superior talents and virtuous industry, may rise from obscurity and poverty to the highest rank and most abundant

affluence. To those who are acquainted with the fortunes of many of the public men of our own day, it cannot be necessary for me to specify instances of this kind, which must at once occur to their recollection. It is gratifying to reflect that we live in a country in which we may point to the man, who, next to the king upon the throne, occupies the highest station in the community, and say with truth, that it was not by obsequiousness and servility, by court-favour or political intrigue, that he rose to his high rank and his splendid fortune, but through the blessing of Providence on the honourable exercise of his own faculties; and, as was truly remarked by my honourable friend who preceded me, it is a delightful consideration, that many a man in a humble and obscure situation, may be cheered and animated in his toilsome and exhausting course, by calling to mind that the same paths to distinction are open to himself also, by which others before him have ascended to greatness and to glory.

My Lord, it is to the free Constitution of this country, it is to the enjoyment of liberty in the administration of equal laws, that we owe these distinguished privileges; and long may a gracious Providence permit them to diffuse among us the same blessings, and to supply similar instances of successful exertion!—My Lord, the very office in which we are now engaged, will tend powerfully to animate our countrymen to similar efforts; and I doubt not that the honour we are now paying to the memory of Mr. Watt, will have the effect

of calling forth fresh exertions of genius and utility, which some successor of your Lordship, at some future meeting, may acknowledge. I could even specify living artificers of their own and their country's glory, who may one day be honoured with similar expressions of applause. I might anticipate the day when an eulogium shall be pronounced on the magnificent labours of a Rennie, and the exquisite sculpture of a Westmacott. May we also, in every instance, my Lord, be able, in commemorating the claims to distinction of some of our superior men, to state, (as I understand from those who enjoyed the privilege of being personally acquainted with Mr. Watt, was eminently the case in this instance,) that they may be not more eminent for the superiority of their mental powers, than for their amiable character in private life. This will stamp additional value on the reputation of those who are the objects of public admiration; and when we shall contemplate the Monument of national gratitude that is to be erected in memory of this great man, in the place in which we record the names of the benefactors and glories of their country, it will be gratifying to reflect, that he who is the object of our present celebration, was not only respected in public, but esteemed and beloved in private life. Let me, then, again congratulate your Lordship on the office you are this day called on to perform;—an office, in the performance of which, you will allow me to say, you receive honour while you confer it. I rejoice that, by taking the chair on this occasion,

you give a proof that you have recognised the true use to be made of rank and influence; that they are given, not merely for private enjoyment, but that they may be employed in such services as you are this day rendering. As the representative of your Sovereign, you could not, I am persuaded, be employed in any office in which his feelings were more in unison with your own, than in praising the extraordinary man on whose merits you have this day pronounced your eulogiums; thereby inviting your countrymen in general to travel in the same paths to honourable distinction; reminding them, by the example this day displayed to their view, that they live in a community in which the blessing of Providence may render them also the instruments of promoting their country's benefit, and their own glory and honour;—let them but have the same claims to distinction, and they will reap the same reward.

The Resolution was then put, and carried unanimously.

Earl of Liverpool.—Gentlemen, I have only now to return you my sincere thanks for the honour you have done me, and to assure you that no honour could have been conferred upon me that I could have valued more, than being placed in the chair on the occasion of our meeting here this day. Gentlemen, I will not detain you by entering further into the subject of this meeting. I have already testified my humble sentiments of the merits of Mr. Watt. I was certain, indeed, that with respect to these merits there could be no difference

of opinion; and it is a gratification to me to feel now, what I hope I shall feel on every other similar occasion, that where the interests of science, and of the fine arts, and of genius are concerned, there is no person more desirous to promote them than myself.

I took the liberty of announcing to you at the beginning of the meeting, the command which I had received from his Majesty. I am sure it cannot surprise you, that he who on every occasion of his life has proved himself to be the patron and friend of science and the fine arts, should desire that his name may be conspicuously brought forward upon the occasion of our meeting here this day. I shall now conclude this meeting by requesting that subscriptions may be opened; I am commanded by his Majesty, as I have already stated, to put down his name for £500, and I beg you will accept from me, as President, £100.

NAMES OF THE COMMITTEE FOR THE ERECTION OF A MONUMENT TO THE LATE JAMES WATT.

The Earl of Liverpool, K.G.
The Earl of Aberdeen, P.A. S.S.
Right Hon. Geo. Canning, M.P. &c. &c.
Right Hon. F. Robinson, M.P. &c. &c.
Right Hon. Robert Peel, M.P. &c. &c.
Right Hon. Wm. Huskisson, M.P. &c. &c.
The Hon. Heneage Legge, M.P.

Sir Isaac Coffin, Bart. M.P.
Sir Humphry Davy, Bart. P.R.S.
Sir James Graham, Bart. M.P.
Sir Robert Peel, Bart.
Sir Walter Scott, Bart.
Sir John Wrottesley, Bart. M.P.
Sir Thomas Lawrence, P.R.A.
Sir James Mackintosh, M.P.
Matthias Attwood, Esq. M.P.
Alex. Baring, Esq. M.P.
Henry Brougham, Esq. M.P.
J. W. Croker, Esq. M.P.
D. S. Dugdale, Esq. M.P.
Davies Gilbert, Esq. M.P.
T. F. Kennedy, Esq. M.P.
E. J. Littleton, Esq. M.P.
T. Frankland Lewis, Esq. M.P.
Francis Lawley, Esq. M.P.
Geo. Philips, Esq. M.P.
Geo. Philips, jun. Esq. M.P.
J. H. Tremayne, Esq. M. P.
Wm. Wilberforce, Esq. M.P.
Rich. Arkwright, Esq.
Sam. Boddington, Esq.
Charles Babbage, Esq.
H. H. Birley, Esq.

Geo. H. Barker, Esq.
M. R. Boulton, Esq.
John Bolton, Esq.
W. T. Brande, Esq. Sec. R.S.
William Clayfield, Esq.
Rev. John Corrie.
William Cotton, Esq.
John Dalton, Esq.
James Davies, Esq.
Peter Ewart, Esq.
Kirkman Finlay, Esq.
Francis Freeling, Esq.
Geo. H. Freeling, Esq.
Rev. T. Lane Freer.
Benj. Gott, Esq.
Charles Hatchett, Esq.
Wm. Henry, M.D.
J. F. W. Herschel, Esq. Sec. R.S.
Francis Jeffrey, Esq.
John Kennedy, Esq.
Geo. A. Lee, Esq.
Thomas Murdoch, Esq.
William Murdock, Esq.
William Mylne, Esq.
George Rennie, Esq.
Joseph Reynolds, Esq.

Richard Sharp, Esq.
William Strutt, Esq.
Joshua Smith Simons Smith, Esq.
C. H. Turner, Esq.
Thomas Telford, Esq.
John Vivian, Esq.
John Woolmore, Esq.
Josiah Wedgewood, Esq.
James Walker, Esq.
James Watt, Esq.

No. IV.

ON MACHINERY, CONSIDERED IN RELATION TO THE WELFARE OF THE WORKING CLASSES. BY M. ARAGO.*

Many persons, without calling in question the genius of Watt, look upon the inventions for which the world is indebted to him, and the impulse which

* In writing this chapter, I have felt myself quite at liberty to make use of many documents which I have collected, both in the course of various communications with my illustrious friend, Lord Brougham, and from the works which he has himself published, or which have appeared under his patronage.

If I were to believe the criticisms which various persons have put forth since this work was read in public, it would seem, that, in endeavouring to combat the opinion that machinery is hurtful to the working-classes, I have assailed an old prejudice which has no real existence,—a mere phantom. I should desire nothing better than to think that it were so, and then I would, with the utmost gladness, suppress all my reasonings on the matter, whether these be good or bad. Unhappily, the letters which well-disposed artisans frequently address to me, both as an Academician, and as a Member of the Chamber of Deputies; unhappily, the very recent dissertations, *ex professo*, of various economists, leave me not a doubt as to the necessity of now again asserting, and reiterating the assertion in every possible form, that machinery has never been the real and permanent cause of the sufferings of one of the most numerous and most interesting classes of society; that the destruction of machinery would make the present state of things far worse; and that it is in no-wise from that quarter that a remedy is to be expected, for evils which I most deeply compassionate.—M. Arago.

these have given to manufactures, as an evil to society. To believe their account of the matter, one would fancy, that the adoption of every new machine inevitably increases the discomfort and misery of the artisans. Those marvellous mechanical combinations, which we are accustomed to admire in the regularity and harmony of their motions, in the magnitude and the delicacy of their effects, would be nothing better than instruments of mischief; and it would be the duty of the legislature to proscribe them with a just and implacable rigour.

Conscientious opinions, especially where they accompany praiseworthy feelings of philanthropy, have a right to receive an attentive examination. I have to add that, on my own part, this examination is an imperative duty. I must, in fact, have overlooked the point of view in which the labours of our illustrious fellow-member are most deserving of the public esteem, if, far from agreeing with the objection that they interfere with the rights of the working classes, I did not direct the attention of men of worth to labours such as those, as the means at once the most powerful, the most direct, and the most effectual, for rescuing workmen from great sufferings, and for calling them to share in numberless blessings, which seemed as if they must for ever have remained the exclusive inheritance of the rich.

When mathematicians have to choose between two diametrically opposite propositions; when, the one being true, the other is necessarily false; and

when it seems that nothing can, *a priori*, lead to a reasonable adoption of one rather than the other, they take these contradictory propositions; they follow them out, with the greatest minuteness, through all their ramifications; they deduce from them their most remote logical consequences; and then, the erroneous proposition, and it alone, hardly ever fails to lead, by this clue, to some results which a sound judgment could not admit. Let us for a moment make use of this kind of scrutiny, which Euclid has frequently employed, and which is appropriately styled the *reductio ad absurdum*.

The enemies of machinery would have it destroyed, or at least prevented from increasing, to keep, they say, more labour in the hands of the working classes. Let us for a moment look at it in this point of view, and it will be found that their anathema applies to much more than to machinery, properly so called.

At the very outset, for instance, we shall be led to tax our ancestors with very great want of foresight. If, in place of founding and so perseveringly extending the city of Paris on both banks of the Seine, they had established it in the midst of the plain of Villejuif,* the water-carriers would for ages have been the corporation at once the best employed, the most indispensable, and the most numerous. Then let our friends, the political economists, set to work to benefit the water-carriers.

* A plain and village on the road from Paris to Lyons.—Tr.

To turn the Seine out of its course, is no impossibility; propose that this labour be commenced; open forthwith a subscription for laying Paris dry, and you will be taught by the universal ridicule, that the *reductio ad absurdum* is of some use even in political economy; in their plain common sense, the working classes will themselves tell you, that the river has created the immense capital in which they find such abundant resources; and that but for it, Paris might still, perhaps, have been nothing better than a Villejuif.

The honest citizens of Paris were hitherto wont to congratulate themselves on the proximity of those inexhaustible stone-quarries, from which, age after age, have been drawn materials for the construction of their temples, their palaces, their private dwelling-houses. It is a mere hallucination! The new economists will prove to you that it would have been very much better, if the lime, the hewn stones, and the rough blocks, could not have been procured nearer than Bourges, for instance. Count on your fingers the number of labourers that must have been employed, on this hypothesis, in bringing to the yards of the capital all the stones, which, for five centuries, our architects have there wrought;—you will find that the sum is quite enormous; and, if you think these new ideas are at all satisfactory, you may exult as you please, at the happiness which such a state of things would have diffused among the working classes!

As to this, let me hazard some doubts; though

I am very well aware, that the Vertots of our time are very like the historian of Rhodes, "*when their siege is done.*"*

The metropolis of a great kingdom, not far distant from France, is traversed by a majestic river, which even ships of war ascend in full sail. Canals intersect the surrounding district in all directions, and transport, at little expense, the heaviest burdens. A complete network of roads, under admirable management, leads to the remotest parts of the kingdom. To these gifts of nature and art, this metropolis, which every one must by this time have named, unites *an advantage* which the city of Paris does not possess; the quarries of stone for building are not at its gates, and are found only at a distance. Here then is realised the Utopia of the new economists. They will, no doubt, reckon by hundreds of thousands, perhaps by millions, the quarrymen, the boatmen, the carters, the engineers, incessantly employed in quarrying, in transporting, in preparing the rough blocks and hewn stones, required for the construction of the immense number of edifices by which that metropolis is annually enriched. They may reckon as

* It is related of Vertot, that "his mode of composition never had made him sensible of the advantage and necessity of accurate erudition. He looked on history more as a literary work, than any thing else; scrupulous exactness as to facts, was, in his eyes, of less consequence than their dramatic effect; and he was not more particular as to truth of colouring. So that he might well reply to those who offered him some curious documents with regard to the Siege of Rhodes, "My Siege is done." See the Biographie Universelle, article VERTOT.—TR.

they please. It happens in the city I speak of, as it would have happened in Paris, if it had been destitute of its productive quarries; stone, being very expensive, is not used; brick is almost everywhere employed in its stead.

Millions of workmen, at the present day, perform prodigious labours on the surface and in the bowels of the earth, which must be altogether abandoned if particular kinds of machinery were to be given up. Two or three instances will be sufficient to make this truth apparent.

The daily removal of the water which rises in the workings of the mines of Cornwall alone, requires a power of fifty thousand horses, or three hundred thousand men. I ask, would not the wages of three hundred thousand workmen swallow up the whole profits of the working?

Does the question of wages and profits seem too delicate? Other considerations will lead us to the same conclusion.

For the working of one Cornish copper-mine alone, (one of the Consolidated Mines), there is required a steam-engine of a greater power than three hundred horses constantly in harness; and which does, in every period of twenty-four hours, the work of a thousand horses. I am not afraid of contradiction when I affirm, that there is no possible way of getting more than three hundred horses, or from two to three thousand men, to work together and to advantage, on an opening so small as the shaft of a mine. To proscribe the Consolidated Mines' engine would, then, be to throw out

of employment the great number of workmen whose labours it renders possible; it would be to declare that the copper and tin of Cornwall should remain there for ever, buried under a mass of earth, of rocks, and of water, many hundred metres in depth. The theory, when put into this form, will certainly have few defenders; but what matters the form, when the ground-work is evidently the same?

If we were to pass from those labours which require the exertion of immense strength, to the examination of various manufactured articles, which the delicacy of their materials, and the regularity of their forms, have caused to be ranked among the wonders of art, the insufficiency, the inferiority of our organs, compared with the ingenious combinations of mechanism, would strike all minds alike. Where, for instance, is the spinner so skilful, as to be able to draw from a single pound of raw cotton, a thread fifty-three leagues in length, as is done by the machine called a Mule-Jenny?

I am not ignorant of all that certain moralists have asserted as to the inutility of the muslins, the laces, the gauzes, which these delicate threads are employed to make; but let it suffice me to observe, that the most perfect mule-jennies are kept in motion under the continual superintendence of a great number of workers; that the whole question, so far as these are concerned, is how to manufacture saleable articles; that, finally, if luxury be an evil, a vice, nay even a crime, the blame of it ought to be laid on the purchasers, and not on

these poor workmen, whose existence would, I fear, be very precarious, if they were to direct their energies to manufacturing for the use of the ladies only coarse cotton stuffs, in place of fashionable gauze.

But to leave all those minute remarks, and to come at once to the great question itself.

"We must not," said Marcus Aurelius,* "adopt the opinions of our fathers, like children, simply because they were held by our fathers." This maxim, undoubtedly very true, ought not to prevent us from believing,—from at least presuming,—that opinions against which, since the origin of society, no objection has ever been brought, must be conformable to reason and the public good. Well then, on the much disputed question as to the utility of machinery, what was the universal suffrage of antiquity? Its ingenious mythology will inform us: founders of empires, eminent lawgivers, subduers of tyrants who oppressed their country, were honoured but with the title of demigods; whereas, the inventor of the spade, the sickle, and the plough, was ranked among the gods themselves.†

I think I already hear our antagonists exclaiming against the extreme simplicity of the instruments I have just mentioned; resolutely refusing

* See M. Aurelius Antoninus De Seipso, IV. lii.—Tr.

† See Lord Bacon, as quoted by Sir James Mackintosh, in his speech at the meeting of subscribers to Mr. Watt's monument in Westminster Abbey. The passage alluded to, occurs at p. 203 of this volume.—Tr.

to them the appellation of *machines*, characterising them only as *tools*, and strongly intrenching themselves behind this distinction.

I might reply, that a distinction such as this is puerile ; that it would be impossible to say precisely where the tool ends, or the machine begins ; but it is more important to observe, that in the pleadings against machines, nothing has ever been said of their greater or less complexity. If they are to be abolished, it is because with their assistance one labourer does the work of many ; and will any one have the hardihood to maintain, that a knife, a drill, a file, a saw, do not give a marvellous facility of execution to the hand that wields them, or that the hand thus aided cannot do the work of a great number of hands provided only with their nails ?

Those workmen stopped not short at the sophistical distinction between a tool and a machine, who, led away by the detestable theories of some of their pretended friends, went through some of the counties in England in 1830, raising the cry of "down, down with machinery!" Rigorous logicians, they broke to pieces in the farms the sickle for reaping, the flail for threshing the corn, and the sieve through which it is winnowed. And what, in reality, are the sickle, the flail, and the sieve, but means of abridging labour ? The spade, the pick-axe, the plough, the drill-plough, could find no quarter with that infatuated band ; and I only wonder that in their fury they should have spared the horse, a sort of machine of comparatively

cheap maintenance, and each of which can every day do the work of six or seven men.

Political economy has happily gained a place among the inductive sciences. The experiment of substituting machines for living beings has been too often repeated of late years, for us to have any difficulty in arriving, henceforth, at general results, amidst some accidental irregularities. These results are the following:

By diminishing manual labour, machinery admits of manufactures being carried on at a cheaper rate; the effect of this reduction in price is an increase in the demand. So great is this increase, and so anxious our desire of comfort, that, notwithstanding the almost incredible diminution in prices, the market value of the whole amount of goods manufactured, annually exceeds what it was before the improvement in the mode of manufacture; the number of workmen employed in each species of manufacture, *increases* with the introduction of more expeditious methods.

This last result is directly the reverse of that which the opponents of machinery desire. At first sight, it might appear paradoxical; but I shall proceed to shew that it follows from even a slight enquiry into the facts which have been best ascertained with regard to labour.

When, three centuries and a half ago, the printing press was invented, copyists were in the habit of supplying books to the very small number of wealthy individuals who allowed themselves to gratify this expensive fancy. One of these copy-

ists, with the help of the new process, being able to do the work of two hundred, men failed not from that time to stigmatise as *infernal*, an invention which, in a particular class of society, could throw out of employment nine hundred and ninety-five persons in every thousand. Let us compare the actual result with the sinister prediction.

Manuscript books were very little in request; printed books, on the other hand, from their low price, were sought after with the greatest eagerness. It was found necessary continually to bring out new editions of the Greek and Roman classics. New ideas, new opinions, gave rise to a multitude of works, some of undecaying interest, others originating in passing events. It has, in short, been calculated, that in London, before the invention of printing, the book-trade gave occupation to not more than two hundred persons; at the present day, they are reckoned by twenties of thousands.

And how would the matter stand, if, putting out of sight the narrow, and, so to speak, material view which I have been compelled to adopt, we were to look at printing in its moral and intellectual phases; if we were to enquire into the influence which it has exercised on public morals, on the diffusion of knowledge, on the progress of human reason; if we were to work out the calculation of the multitude of books which we owe to it, which the copyists would certainly have despised, and from which, genius daily derives the elements of its teeming conceptions? But I call to mind that at present

we are to enquire only into the number of workmen employed in each kind of manufacture.

That of cotton, even more than printing, presents us with most convincing facts. When an ingenious barber of Preston, Arkwright, who, by the way, left to his family a fortune of from two to three millions of francs, substituted, with advantage and profit, revolving cylinders in place of the fingers of female spinners, the annual produce of the cotton manufacture in England was only fifty millions of francs; now, this produce is more than nine hundred millions of francs. In Lancashire alone, there is every year employed in the manufacture of calico, a quantity of yarn which twenty-one millions of expert female spinners could not make with the aid only of the distaff and spindle. Thus, though in the cotton-spinning trade mechanical contrivances have been carried to their utmost length, a million and a half of workmen now find employment, where, before the inventions of Arkwright and Watt, not more than fifty thousand could be numbered.*

A philosopher once exclaimed, in a fit of deep despondency, "there is nothing new brought forward now-a-days, unless we call that new which has been forgotten." If he meant to allude only

* Mr. Edward Baines, the author of a much esteemed history of the cotton manufacture in Britain, has had the strange curiosity to enquire what length of thread is annually employed in the fabrication of cotton stuffs. He has found that the total length so employed is equal to fifty-one times the distance of the sun from the earth; *i. e.* fifty-one times thirty-nine millions of post leagues, or about two thousand millions of the same leagues!—M. Arago.

to errors and prejudices, the philosopher spoke the truth. Past ages have been so prolific of these, that they can hardly have left to any one the advantages of priority. Thus the pretended philanthropists of modern times have not even the merit, (if merit it be), of having invented the systems which I am now examining. Look at poor William Lea, exhibiting the first stocking-loom at work, in the presence of King James I.! The mechanism seemed admirable; why was it not adopted? On the pretext that the working class would suffer by it. France shewed an equal want of foresight; William Lea met with no encouragement there; and at last he died in a hospital, like so many other men of genius who have had the misfortune to get too far in advance of their age!

But again, you would be much mistaken if you were to suppose that the corporation of stocking-weavers, to whom William Lea then fell a victim, was very numerous. In 1583, stockings were worn only by persons of high rank and large fortune. The middle classes used in place of that part of our dress, narrow bands of different stuffs. The rest of the people, nine hundred and ninety-nine out of every thousand, went bare-legged. Now, in a thousand individuals, not more than one is prevented from purchasing stockings, in consequence of their too high price. And an immense number of workmen are occupied in every country in the world, in this species of manufacture.

If it were thought necessary, I could add, that at

Stockport the substitution of power-looms for manual labour has not prevented the number of workmen from increasing by a third, in a very few years.

We must, in conclusion, take from our antagonists their last resource; they must no longer have it in their power to allege that we have mentioned none but old kinds of manufactures. I shall, then, shew how greatly they have of late times been mistaken in their melancholy predictions, in regard to the results of engraving on steel. "A copper-plate," said they, "cannot give more than two thousand impressions. A steel plate which gives a hundred thousand without being worn out, will come in the place of fifty plates of copper. Do not these numbers prove, that most of the engravers, —forty-nine out of every fifty,—will find themselves compelled to leave their engraving rooms, to change the graver for the pick-axe and trowel, or to implore in the streets the compassion of the public?"

Once more, for the twentieth time, prophets of evil! beware that you forget not, in your lucubrations, the most important point in the problem which you pretend to solve! Think of the insatiable desire of happiness which nature has implanted in the mind of man; think how one want, when gratified, instantly raises up another; how all our appetites increase with the facility of their gratification; and so as to set at defiance the creative faculties of the most powerful engines.

Thus,—to return to engravings,—the great ma-

jority of the public dispensed with them when they were high-priced; as their price is lowered, they are sought after by every one. They have become an essential ornament of the best books; they give indifferent books some chance of selling. Even in almanacks, the antiquated and hideous figures of Nostradamus, or Mathieu Laensberg, are now replaced by picturesque views, which, in a few seconds, carry our citizens, without the necessity of moving, from the banks of the Ganges to those of the Amazons, from the Himalayas to the Cordilleras, from Pekin to New York. And look at those engravers, whose ruin was predicted to us with such sad forebodings: they never were either more numerous, or better employed.

The facts I have just mentioned are incontrovertible. I think they will prevent it being maintained that on this earth, and among its inhabitants, at least such as Nature has made them, the use of machinery can ever cause any diminution in the number of workmen employed in any species of manufacture. Different habits, different manners, different passions, might perhaps have led to totally different results; but this topic of speculation I leave to those who may intend to compose treatises on the economy of labour, for the use of the inhabitants of the Moon, of Jupiter, or of Saturn.

Placed in a much narrower sphere, I ask myself the question, whether, after having sapped at its foundation the system of the opponents of machinery, it is still requisite that I should glance at

some objections in detail? It is almost unnecessary, for instance, to remark, that the poor-rates, that ever bleeding wound of the British nation, that wound which some try to ascribe to the abuse of machinery, is to be dated from the reign of Elizabeth; from a period two centuries earlier than the labours of an Arkwright and a Watt.

"But," say they, "you will at least admit, that steam-engines, and mule-jennies, and the machines used for carding, printing, etc., which you so greatly admire, have not prevented pauperism from increasing and spreading?" This novel admission I am quite ready to make. Did any one ever uphold machinery as a universal panacea? Did any one ever pretend that it had the unheard-of power of banishing error and passion from political assemblies; that it would lead the counsellors of princes in the paths of moderation, wisdom, and humanity; that it would turn Pitt away from his incessant interference in the affairs of the neighbouring nations; from raising up, year after year, enemies to France in every part of Europe; from keeping them in pay by large subsidies; and, finally, from loading England with a debt of several millions? There, there is the true reason of so rapid and prodigious an increase of the poor-rates. Machinery has not, and could not have produced this evil. I dare even affirm, that it has very much diminished it, and I prove it in a single sentence:—Lancashire is the greatest manufacturing county in the whole of England; it is in that county that we find the towns of Manchester,

Preston, Bolton, Warrington, and Liverpool; it is in that county that machinery has been most suddenly and most generally introduced. Well then, let us divide the whole annual amount of poor-rates in Lancashire among the whole number of the population; let us, in other words, find out the proportion due by each individual, and we shall have a result nearly thrice as small as the average of all the other counties. You see that numerical ciphers have no mercy on the framers of systems.

In conclusion, let not those dreaded words, the poor-rates, make us believe, on the faith of some vague declaimers, that among our neighbours, the working classes are entirely destitute of resources and of foresight. A work of recent date has shewn, that in England alone, (Ireland and Scotland being left out of view,) the capital belonging to workmen only, which is deposited in the savings-banks, is nearly four hundred millions of francs. The census taken in the principal towns is not less instructive.

One principle alone has remained uncontested amidst the keen disputes to which political economy has given rise; this is, that the population increases with the general prosperity, and that it diminishes rapidly in times of distress.* Let us see how facts bear out this principle.

While the average population of England increased, during the last thirty years, by fifty per cent., Nottingham and Birmingham, two of the

* Ireland is an exception to this rule; but the cause of this is well known, and I shall have occasion elsewhere to speak of it.—M. Arago.

greatest manufacturing towns, shewed a still further addition of twenty-five and forty per cent. Finally, Manchester and Glasgow, which hold the first rank in the whole British Empire, for the number, the size and the importance of the machines which they employ, saw their population, in the same period of the last thirty years, increase by a hundred and fifty and a hundred and sixty per cent. This was an increase three or four times greater than in the agricultural counties and the towns not manufacturing.

Numerical statements such as these speak for themselves. No sophistry, no false philanthropy, no exertions of eloquence can resist them.

Machinery has given rise to a particular kind of objection, which I ought not to pass over in silence. At the moment of its introduction, at the moment when it begins to replace manual labour, certain classes of workmen suffer by the change. Their honourable, laborious industry is almost at once destroyed. Even those who, under the old system, were the most skilful, being sometimes destitute of the qualities which the new process requires, remain unemployed. They are seldom able to betake themselves all at once to other kinds of work.

These reflections are just and true. I would add, that the melancholy consequences which they display, must frequently recur; that some caprices of fashion are sufficient to produce very great wretchedness. If I do not thence draw the conclusion, that the world should remain stationary, God forbid that, while I desire advancement in

the general interests of society, I should pretend that it can turn a deaf ear to the individual sufferings of which that advancement is the temporary cause! The law, always on the watch for new inventions, seldom fails to reach them by financial enactments; would it be requiring too much of it, to demand that the first contributions levied on genius should go to establish particular workshops, where workmen suddenly thrown out of employment might find, for some time, an occupation suited to their strength and intelligence? This way has sometimes been followed with success; it has only to become general. Humanity makes it a duty,—it is dictated by sound policy; if other argument were needed, some frightful occurrences of which history has preserved the remembrance, would recommend it also in an economical point of view.

To the objections of those theorists who feared that the progress of mechanical science would reduce the working classes to a state of complete inaction, have succeeded difficulties of quite an opposite kind, about which it seems necessary to pause for a few moments.

By dispensing in manufactories with all operations requiring physical strength, machinery leads to children of both sexes being there employed in great numbers. This frequently gives rise to abuses on the part of overseers and avaricious relations. The time devoted to labour exceeds all reasonable bounds;—for the daily bribe of eight or ten centimes, intellects which a few hours of study would have rendered productive, are devoted to

interminable brutalisation; bodily organs, which, for their developement, would require the open air and the genial influence of the sunbeams, are condemned to miserable weakness and deformity.

To require the legislature to put a stop to this hideous grinding of the poor man by the rich; to petition for enactments to oppose the demoralisation which is the ordinary result of bringing together large numbers of young workers; to endeavour to introduce and to multiply certain machines in cottages, that, in the course of the seasons, the labours of agriculture may be united to mechanical toils, is to do an action at once patriotic and humane, to shew a true acquaintance with the real wants of the working classes. But obstinately to persist in effecting by the hand of man, with great difficulty and at great expense, labours which machinery performs instantaneously and at a cheap rate; to make working men resemble brutes,—to require of them daily exertions which ruin their health, and which science can achieve a hundredfold more readily by the aid of wind, or water, or steam,—this were to go directly contrary to the object desired to be attained; this were to devote the poor to nakedness; to reserve for the rich, exclusively, innumerable blessings which at present are shared by all; this were, finally, to return from comfort and cheerfulness to the ages of ignorance, of barbarism, and of misery.

It is time to quit this subject, though I am far from having exhausted it. I may not, indeed, have triumphed over a phalanx of inveterate systematic prejudices, but I may, at least, hope that my plead-

ing will gain the concurrence of those thousands and thousands of idlers in the metropolis, whose life is spent in reconciling their taste for pleasure with the care which their ill health demands. In a few years, thanks to the discoveries of Watt, all these Sybarites, rapidly conveyed by steam on railways, may, in short space, visit all parts of the kingdom. In a single day they may go and see our naval force fitting out at Toulon; breakfast at Marseilles on the juicy mullets of the Mediterranean; plunge, at noon, their enervated limbs in the mineral waters of Bagnères; and return, in the evening, by Bordeaux, in time for the ballet at the opera! Is this denied? Then I say, that the trip I have sketched out requires only a pace of twenty-six leagues an hour; that various trials of steam carriages have already realised a velocity of fifteen leagues; and, lastly, that Mr. Stephenson, the celebrated Newcastle engineer, offers to construct engines which shall go twice and a half as fast,—engines which shall go forty leagues within the hour!

THE END.

EDINBURGH: PRINTED BY T. CONSTABLE,
PRINTER TO HER MAJESTY.